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1 INTRODUCTION AND OVERVIEW

This is a draft plan for habitat restoration in the Green/Duwamish River Watershed. The purpose of this document is to demonstrate how the Preferred Alternative from the Programmatic EIS will look if it were implemented. Previous analysis in the EIS and reconnaissance report has demonstrated, from an aquatic habitat standpoint, that the Green/Duwamish has experienced a variety of impacts over the past 100 years. Urban and industrial development, flood control, and deforestation are a few of the disturbances that have kept much of the river in a degraded condition since 1959. The recent listing of chinook salmon and bull trout under the Endangered Species Act is a further example of the decline of habitat conditions in the watershed.

The Draft Restoration Plan presents a balanced and reasonable approach to restoration. This plan does not propose to rectify all of the pressing issues of restoring and maintaining natural resources in one of the most rapidly developing watersheds in Washington. The restoration described in this plan does not suggest a return to historic conditions, nor does it address all of the important management and regulatory initiatives. While these management and regulatory issues were considered in the development of the plan, their resolution is left to more appropriate forums, such as the Tri-County initiative and the Water Resource Inventory Area (WRIA) 9 conservation planning efforts. This plan focuses on a set of restoration options that could be readily implemented.

What has come out of the planning of the Ecosystem Restoration Study is a focus on capital improvement projects that can provide immediate and long-term benefits to the aquatic portions of the Green/Duwamish system. From a habitat standpoint, the Preferred Alternative discussed in the Programmatic EIS proposes to improve ecological functions for a variety of aquatic species over the entire watershed, by focusing on restoring riverine processes where possible. Where this is not possible, the plan proposes recreating aquatic habitats that were historically present but are now diminished. The proposal also considers the current condition of the valley, its residents and social needs. The planning effort focuses on returning habitat functions without changing flood conditions or removing existing infrastructure.

As a result of the planning effort, the blueprint for restoration is a combination of activities. The plan considers both the spatial and temporal aspects needed for restoration and proposes a variety of project types. The constructed habitats included in the plan provide an immediate benefit for fish and wildlife and are location-specific based on life history needs of the affected species. These constructed projects such as creation of off-channel rearing areas or excavation of intertidal habitat in the estuary will be implemented first.

Based on the analysis performed for this plan, the most beneficial and long-term solution that could occur will be to restore the natural hydrologic regime where possible. This approach uses the natural fluvial processes that create aquatic habitat. Currently, the most likely areas for this form of restoration to occur will be from below the Tacoma Diversion Dam (RM 61) to the State Route 18 bridge (RM 30). This stretch of the river is the least populated and the river is still active within the floodplain. In that area, the approach is to provide the sediment, wood, and land area that will allow the river to create its own natural meander beds, multiple channels, and sloughs, and to recruit wood and replenish spawning gravels.

While this Draft Restoration Plan is a significant accomplishment, it is not intended to be the complete answer to the resource problems in the Green/Duwamish Valley. However, it is an important first step in balancing resource needs with other competing uses. In order for balance to be achieved, other changes (such as land use, fisheries management, and regulations) must also occur.

The ambitious program presented in this Restoration Plan cannot be implemented without the assistance of the general public. Fifty projects have been identified that will be constructed over the next 10 years. This is a voluntary program, since some of the proposed projects will occur on private property. All of the property owners have not been contacted prior to release of this document, but this will be done over the next few months. Landowners will receive all of the documentation leading to implementation of the project, and a reasonable settlement will be negotiated. If the current landowners do not wish to be included in the program, similar replacement sites elsewhere on the river will be sought.

Again, it is important to note the voluntary nature of the program. In areas where riparian buffers are discussed in the document, they are idealized. Every attempt will be made to negotiate the widest buffer practicable. Where site constraints or land ownership is in conflict, the best buffer available will be obtained without compromising the biological integrity of the project.

The scale of restoration activities to be taken by this plan will depend upon the funds, property, and services made available through the combination of funding sources.

1.1 Purpose and Need

It is the intent of this Restoration Plan to improve the overall health of the Green/Duwamish River ecosystem for fish and wildlife species by restoring (increasing) the amount and quality of spawning and rearing habitat, as well as water quality.

The overall objective of the draft plan is to restore river ecosystem functions and processes to a more natural condition throughout the watershed. To accomplish this objective, the following basin-wide restoration goals were identified:

- Improve the physical nature of existing degraded habitat.
- Improve existing ecosystem functions and values. This includes improving riverine processes where reasonable.
- Address important factors limiting habitat productivity.

The need for restoration is based on studies of the Green/Duwamish River Basin conducted by the U.S. Army Corps of Engineers (Corps), King County, and other agencies. Habitat degradation was most recently evaluated in the Ecosystem Restoration Study (ERS) reports conducted by the Corps (1997), the King County Limiting Factors Analysis (Fuerstenberg et al.

1996 and Appendix B in Corps 1997) and the U.S. Forest Service's Green River Watershed Analysis (1996). These evaluations identified several major problems in the basin as shown in Table 1. Table 1 also presents the relationship of basin-wide restoration goals to the major resource problems identified to date.

As a result of the extensive study and public focus, the Green/Duwamish River has been identified as a National Showcase Watershed. Information about National Showcase Watersheds can be found at the Green/Duwamish website (http://www.epa.gov/owow/showcase/duwamish).

Table 1. Relationship of the Basin-wide Restoration Goals to Resource Problems in the Green/Duwamish Watershed

Resource Problems	Restoration Goals		
	Change the Physical Nature of Existing Degraded Habitat	Improve Existing Ecosystem Functions and Values	Address Important Factors Limiting Habitat Productivity
Lack of habitat in the Lower Green/Duwamish Estuary	X		X
Changes in sediment loads and transport	X		X
Loss of channel complexity and in-channel structure	X	X	X
Water quality degradation		X	
Barriers to fish passage		X	
Floodplain disconnection	X	X	
Habitat fragmentation	X	X	X
Degradation of wetlands and rare species habitats	X		
Changes in forest structure and composition	X	X	X

In addition to the existing resource problems, land uses in many of the subbasins within the study area are changing, and development may further exacerbate some problems. The resolution of land use and resource conflicts is being addressed through the WRIA 9 planning effort, which is being coordinated with the ERS.

1.2 Overview of Green/Duwamish River Basin

The Green/Duwamish River Basin includes 483 square miles of King County and portions of 13 incorporated cities, located in WRIA 9 in west-central Washington (Figure 1). The Green River Watershed originates in the Mt. Baker-Snoqualmie National Forest in the Cascade Mountains of southeastern King County, south of Stampede Pass, at an elevation of about 4,500 feet. The river flows northwest 90.5 miles to Elliott Bay (Figure 2).

Throughout its course, the Green River passes through Howard A. Hanson Dam (HHD), at river mile (RM) 64.5, and the Tacoma Diversion Dam (RM 61.0). The river then descends through the Green River Gorge, from RM 57.0 (Corps 1997). Between Flaming Geyser State Park (RM 44.0) and State Route 18 (RM 34.0), the river traverses farmlands, open space, and lands owned by King County. Near the old White River confluence, the river enters the broad and heavily urban lower Green River Valley. Levees become common on one side of the river in the middle Green River Valley at the City of Auburn (RM 31.0) and are found on both sides of the river in the Cities of Kent and Tukwila. Levee maps of this area commonly show gaps in the system, but these are typically areas of river terrace or "high bank" where the floodplain is not accessible to the river. The river is heavily channelized in these areas to the mouth.

The "upper basin" is defined as starting at the crest of the Cascade Mountains and ending at Tacoma Diversion Dam (RM 61.0) (Figure 2). The "middle basin" is defined as starting at Tacoma Diversion Dam and ending at the tide water effect (about RM 11) (Figure 2). The "lower basin" (and estuary) is defined as starting at the tidally affected area in the historic Duwamish River (RM 11) and ending at Elliott Bay, on the Seattle waterfront (Figure 2).

1.3 Other Planning Efforts

1.3.1 Regional Needs Assessment

The Regional Needs Assessment (RNA) is a county-wide effort to identify, quantify, and develop funding strategies for implementation of regional water resource projects related to flooding, water quality, and aquatic habitat. King County, Seattle, and all of the suburban cities within King County are participants in this effort. The Green Duwamish Watershed Forum was established in 1997 to provide a framework for local governments to work cooperatively on these regional uses in this watershed. The interlocal agreement supporting the ERS was adopted by the individual jurisdictions comprising the Forum.

The RNA process resulted in identification of approximately $250 million in water resource projects, including over $50 million in the Green/Duwamish River Watershed. Many of the projects in the Preliminary Restoration Plan for the ERS are included in the RNA project list, and this may provide all or a portion of the local matching funds for ERS design and construction. The RNA is now moving into a phase of specifically evaluating a variety of strategies to fund identified projects.

1.3.2 WRIA 9 Planning Process

In May 1999, the National Marine Fisheries Service listed Puget Sound chinook salmon as threatened under the Endangered Species Act. Local and state governmental agencies in this region have since looked for ways to cooperatively develop strategies to address the needs of this species through conservation planning, early project implementation, and related measures. Within the Green/Duwamish River Watershed, this has led to development of a conservation planning process for WRIA 9. WRIA 9 encompasses the Green/Duwamish River Watershed and several independent drainages that drain directly into Puget Sound between South Seattle and Federal Way.

A conservation plan is being developed by a steering committee composed of federal, state, and local government representatives, and business and environmental representatives. This plan will evaluate a range of strategies to conserve salmonid habitat, including land use practices, policies, and regulations, improvements to governmental programs such as roadway and levee maintenance, and acquisition or restoration of aquatic lands. This last item clearly overlaps the focus areas of the ERS and, with many of the same participants involved in both projects, the ERS could serve as a significant project development component of the WRIA 9 plan.

2 IDENTIFICATION OF RESOURCE CONDITIONS

In 1995, a group of agencies, municipalities, and Tribes in the Green/Duwamish River Basin recognized the need to improve the natural resources in the basin. The King County Water and Land Resources Division and the City of Kent cohosted interagency meetings in 1995 to provide an arena to share information about ongoing restoration planning and implementation activities in the watershed. Although funding was being provided for habitat enhancement and restoration for individual projects, there was no coordination of such efforts on a watershed scale. Additionally, problems throughout the basin could not be addressed, analyzed, or prioritized with the existing resources. The meetings resulted in the formation of the Watershed Restoration Group, which included federal, state, local agencies, the Muckleshoot Indian Tribe, and several community and environmental groups. It became evident from these meetings that many projects were recommended but not funded because the planning efforts did not take into account the jurisdictional boundaries, which were needed to approach the appropriate jurisdictions as funding resources.

The Corps and King County joined forces to form an Environmental Restoration Study Team to establish the Ecosystem Restoration Study (ERS) to resolve ecosystem problems within the river basin. The ERS provides the context, framework, and priorities for basinwide capital improvement type restoration as well as funding for restoration projects. King County is an official sponsor that has a supporting interlocal agreement among many of the watershed's cities to fund study efforts. Many of the agencies and community groups have contributed time and effort to develop study findings, and to select and prioritize projects. This study has focused on restoration activities instead of larger issues within the watershed, such as land use management. These larger issues will be addressed at a later time, in more appropriate forums such as the Tri-County initiative.

2.1 Projects Underway Prior to the ERS

A number of individual habitat restoration projects had been or were being implemented at the time of formation of the ERS. These projects provided an incremental improvement to habitat conditions in the watershed, and represented important first steps to reversing the deterioration of habitat conditions in the watershed. However, one of the limitations of those projects was the lack of an integrated approach to restoration. These projects included the following:

- Several federal efforts, including the Coastal America program, have resulted in restoration at small sites along the Duwamish River, but funds have been limited to "demonstration" projects. A settlement under the Natural Resource Damage Assessment program has also resulted in both acquisition and restoration of key sites along the estuary.

- Little restoration has occurred along the lower Green River, a portion of the river highly constrained by past levee construction and dense floodplain development. Levee maintenance programs, under the auspices of the Green River Flood Control Zone District, have incorporated habitat structures such as large woody debris (LWD) and riverbank plantings of native vegetation into repair sites. A main objective of the levee maintenance program consists of levee setbacks which allow increased flood conveyance and provide a greater total area of riparian habitat.

- Planning efforts have been underway in several subbasin tributary streams, such as Mill Creek (City of Auburn), Springbrook/Mill/Garrison Creeks, and others. To date, large-scale implementation of these plans has also been largely unfunded.

- Implementation of the Soos Creek Basin Plan, adopted by the King County Council in the early 1990s, has led to a coordinated approach to restoration in this important tributary within the middle Green River, the largest of the three subbasins. However, the priority of Soos Creek restoration, relative to other needs throughout the watershed, has not been established.

- The Waterways 2000 program has resulted in acquisition of approximately 1,000 acres of land along the middle Green River, specifically for habitat protection. Funds generally have not been available to restore aquatic lands in this reach.

- Local groups, such as the Mid-Sound Fisheries Enhancement Group and Trout Unlimited, have conducted projects to improve riparian vegetation throughout the watershed. Projects have included plantings along the streambanks and riparian zone, streambank fencing in agricultural areas, and some localized channel improvements along tributaries of the Green River, most notably Newaukum Creek. These efforts have not been fully coordinated or prioritized.

- The Corps and the City of Tacoma have been evaluating approaches to augmenting instream flows during the summer low-flow season through the Additional Water Storage Feasibility Study. This project evaluates the alternative of increasing the height of the conservation pool at HHD (Corps 1998). Additionally, Tacoma Public Utilities is conducting an ongoing Habitat Conservation Plan.

- Plum Creek Timber Company, the U.S. Forest Service, the Washington Department of Natural Resources, and others have initiated several planning efforts to restore or mitigate forest practices impacts in the upper watershed.

- The Regional Needs Assessment (RNA) as previously discussed in Section 1.

- The conservation planning process for WRIA 9 and the Tri-County Forum is to address the needs of the threatened chinook salmon through conservation planning, early project implementation, and related measures.

- The Green Duwamish Watershed Forum was established in 1997 to provide a framework for local governments to address regional uses in the watershed.

- Projects initiated by the Corps, King County, and Port of Seattle under Section 1135 at Turning Basin and Puget Creek.

- Natural Resource Damage Assessment (NRDA) projects such as those initiated by Seaboard Lumber, Kenco Marine, and North Wind Weir.

- Washington State Department of Transportation (WSDOT) improvements under the First Avenue Bridge.

2.2 Conditions Study

During 1995 and 1996, the ERS team participated in and prepared a General Investigation (GI) Reconnaissance Phase Report (Corps 1997). The Reconnaissance Study utilized a variety of information sources to define the restoration needs of the Green/Duwamish Watershed. These included:

- A basin analysis of the history of human development in the basin, comparison of historical and current physical and biological conditions, and summarization of the significance of those changes for fish and wildlife resources. Specific subbasin problems were described. A similar approach was previously used by the U.S. Forest Service for the upper watershed analysis (1996).

- A Limiting Factors Analysis by the King County Department of Natural Resources, Surface Water Management Division (Fuerstenberg et al. 1996). This analysis identified and described the fundamental impediments to ecosystem function within the Green/Duwamish River and its associated floodplain.

- Technical workshops to solicit input from representatives of various governmental entities, natural resource agencies, and Tribes. The workshops clarified certain problems, illuminated the applicability of existing databases, and produced recommendations for potential restoration projects.

- Studies to identify problems within the estuarine portion of the system, including a historical overview of the habitat loss (Blomberg et al. 1988). These studies were consulted during the preparation of the Reconnaissance Report.

- A variety of existing spatial databases into a single, coordinated Geographic Information System (GIS) by the reconnaissance study team. Databases included topographic and physical feature coverages, identifying particular areas of concern such as tributary blockages and priority species habitats (Washington Rivers Information Systems and Priority Habitat and Species databases), King County databases relating to habitat features within the river and adjacent riparian zones, and a land use classification coverage developed specifically for this project.

All of these resources were employed to develop an overview of problems affecting ecosystem functions within the study area. A majority of the problems relate directly to 140 years of human modification of river processes, including large-scale water diversions and flow regulation, channel stabilization and simplification, and extensive modification of floodplain and riparian plant communities.

The result of this investigation was the identification of the principal resource problems identified in Table 1.

2.3 Limiting Factors Analysis

The Limiting Factors Analysis focused on the fundamental river and riparian processes that form and maintain habitat such as streamflow, sediment transports, and inputs and distribution of nutrients and woody debris. Modifications in these fundamental processes tend to have far-reaching impacts, at times influencing the characteristics of habitat in the entire river system. While a restoration project at an individual site can have great benefits in a small area, maintenance or restoration of a fundamental river process can have benefits throughout the watershed. The Limiting Factors Analysis included an extensive analysis of historical conditions in the Green/Duwamish Watershed in order to understand major changes in river processes and their consequent impacts on habitat. In addition, other reports analyzed the sediment and large woody debris distribution and effects within the Green/Duwamish Watershed.

2.3.1 Barriers to Fish

The populations of many anadromous fish species have been severely reduced within the Green/Duwamish Watershed. Two major dams and many impassable flap gates, culverts, and weirs in the basin effectively block salmonid passage to more than half of the potential habitat in the basin. Downstream migrating fish must pass HHD through the main outlet gates or the 48-inch bypass pipe. Fish passage studies conducted by the Washington Department of Fisheries in 1984 suggest that as depth over the bypass exit increases during spring refill, outmigrating anadromous salmonids are less able to find and enter the bypass exit (Seiler and Neuhauser 1985), and are delayed within the reservoir until the final fall drawdown (Dilley and Wunderlich 1992).

2.3.2 Reduction in Channel Forming Flows

The construction of HHD resulted in a reduction of high flooding flows that are essential in reshaping the floodplain by forming channel bars, braids, and side channels. The resulting loss of these river features has resulted in a significant decline in the diversity of habitat for salmon, which use off-channel habitats for spawning and rearing. The reduced flows and absence of spring freshets may prolong downstream migration of juvenile salmonids, thereby making juvenile salmonids more susceptible to predators and adverse water quality conditions (Fuerstenberg et al. 1996).

2.3.3 Loss of Channel Diversity in the Lower River

Little channel diversity exists on the lower Green River due to the reduction in flow delivered to the lower reaches and the development of extensive levee systems. The levee systems disconnect the mainstem from floodplains, reducing the river to a single, non-migratory channel. In reaches confined by levees, the cross section of the river efficiently transports water but inefficiently transports sediment, resulting in the storage of sediment that has moved from the eroded areas (Fuerstenberg et al. 1996). Channelization and construction of levees reduce habitat complexity by creating and maintaining a single, deep, uniform channel, which results in fewer river miles, less shoreline and estuary, and an overall decrease in channel length, channel and estuary shoreline (ratio of 2.2 to 1).

2.3.4 Loss of Estuarine Habitat

The lower river has been dramatically altered, resulting in a loss of more than 97 percent of the original wetland area. Dredging and filling in the immediate area of the estuary have physically replaced the features of the estuary, substituting a uniform deep channel bounded by intensively developed uplands for the former complex system of estuarine mid-depth channels, intertidal flat, and fringing tidal marshes. (Blomberg et al. 1988.) Many areas of the floodplain have been converted to other uses. This has dramatically reduced the interchange of water and materials between the aquatic and terrestrial systems and has isolated floodplain wetlands. Many tributaries and wetlands have been separated from the mainstem river by development.

The alteration of the estuary has resulted in a non-functioning estuarine system. The amount of habitat within the watershed has been reduced, freshwater input pollutant loading has risen, dissolved oxygen levels have decreased, and refugia have become diminished. Additionally, invertebrate food organisms have declined, limiting the food source for juvenile salmonids. The overall outcome of these changes in habitat and function is a shorter residency and lower growth rate of juvenile salmonids and less net survival (Blomberg et al. 1988).

Fish habitat in the lower basin is generally limited and significantly degraded by the armoring of the river banks and urban/industrial development. Historically, all of the anadromous Pacific Northwest salmonids were present, but today chinook, chum, and coho are the most abundant juvenile salmonids present (Warner et al. 1995). Blomquist's (1996) study of fish habitat did not inventory the lower basin in detail because it essentially found that no high-quality fish habitat existed.

2.3.5 Loss of Floodplain Habitat

Many fish and wildlife species are dependent on the natural seasonal variations in streamflow that occur in free-flowing rivers to time their migrations, reproduction, and other behaviors. Since the HHD was built, much of the natural variability in streamflow has been lost, replaced by a highly regulated flow regime. For example, flows that occur once every 100 to 200 years will be almost identical to those that flow every 5 or 10 years except in duration (i.e., the volume remains the same) because the dam will not exceed 12,000 cfs. Fundamental to the form of a river is the hydrologic regime, which produces seasonal and decadal patterns of floods and drought. The historic patterns of channel migration, braiding, erosion, and deposition were for the most part controlled by floods. The river's ability to transport sediment, migrate across the valley floor, or inundate a significant portion of the floodplain has been significantly reduced since the implementation of HHD and numerous levees. Given the dam operation, flows sufficient to cause large-scale channel avulsions are unlikely to occur more frequently than once in 100 or 200 years (Fuerstenberg et al. 1996). Construction of levees and revetments has also contributed to the river's inability to carve or even flood some side channels.

Alteration of the flow regime affects the side channels in another significant way. During overbank flows, when adjacent floodplains are inundated, floodwaters seep into the floodplain, recharging the water table. This supply slowly drains toward the river over the year, supplying small floodplain streams, side channels, and even the river itself with cool flows late in the season. Without the inundation, the process cannot occur and floodplain streams and side channels dry up earlier in the season and river temperatures may be affected. Reduced flows also reduce water supply to the banks and geomorphic surfaces within the active channel, thereby reducing bank storage and affecting riparian growth.

Growth rates and survival of typical riparian species decrease with reduced soil moisture conditions. This leads to an overall reduction in riparian width and replacement of riparian species with species tolerant of the drier conditions. From a historical perspective, the construction of HHD resulted in a loss of 64.5 miles of tributary, 2.8 miles of tributary side channels, 25.3 miles mainstem, and 6.9 miles mainstem side channel spawning habitats due to inundation (Cutler pers. comm.). Flood control operations have disconnected the mainstem channel from its floodplain through reduced peak flows. Similarly, changes in flow regimes have reduced the channel-forming effects of high flows and largely curtailed sidechannel formation and similar dynamic patterns in the mainstem. At the same time, extensive logging has had significant effects on water storage and infiltration, reducing low flows and runoff patterns.

2.3.6 Reduction in LWD Recruitment and Riparian Functions

Primary functions of riparian zone vegetation with respect to salmon habitat are: buffer for water temperature changes, nutrient recycler, habitat and reproductive corridor for vegetation and wildlife, area of high species diversity, and source of LWD that contributes to in-stream habitat diversity important for salmon survival. The riparian zone vegetation and structure of the river have been radically altered since the early 1900s, resulting in the decline of the functions connected to riparian zone vegetation for almost 100 years (Fuerstenberg et al. 1996). The dam reduces flow volume and rate, and sediment passage; the levees and revetments reduce river migration rates. This reduces the frequency and extent of sediment, slowing the natural progression of plant succession that normally occurs in the riparian zone.

Typically, large floods remove trees along the river's edge, deposit sediment in the floodplain, and move river channels. Historically, conifers composed the majority of the riparian vegetation. Today the riparian zone in the middle and lower basins is much different, consisting of 1 to 4.8 percent conifer, 33 percent deciduous, 33 percent shrub, 37 percent pavement and buildings, and 1 percent intertidal (Fuerstenberg et al. 1996). Figure 20 in the Corps Reconnaissance Report (Corps 1997) shows how existing land uses have modified the riparian zone.

Reduction of the conifer coverage reduces the variety and abundance of in-stream habitat types important for salmon survival such as deep pools, gravel beds, and areas of slow water which are all associated with woody debris in streams and rivers. Woody debris increases the in-stream diversity of habitat and influences salmon populations by accumulating areas of gravel suitable for spawning, by slowing water flow, and by producing cover and resting habitat for fish.

An absence of large wood in the river channel contributes to low channel complexity in the mainstem Green River. Elimination of the supply of naturally recruited large wood through historical and ongoing timber harvest throughout the Green River Watershed contributes to the absence of in-stream wood. The functional jams on the river today appear to have formed from recent bank erosion of riparian forests. Most of the key pieces that anchor the jams are large cottonwoods, and none are old-growth conifers (Perkins 2000). Perkins (2000) recommended woody debris goals, which focused on meander and bar apex debris jams and the size of debris needed to form stable jams, rather than piece numbers or wood volume.

Meander jams have two or more key members that deposit at the upstream head of a point bar parallel to bankfull flow (Abbe and Montgomery 1996). The key members usually have rootwads facing upstream. Racked members accumulate perpendicular to the key member rootwads, stacking up on each other. The meander jam forms a stable revetment as the river migrates laterally, and hence may tighten bend curvature and change flow orientation relative to the jam.

Bar apex jams are composed of a key member and smaller members that rack up against the key members and on the flanks of the key members (Abbe and Montgomery 1996). Jam formation begins with deposition of a large log with its rootwad facing upstream. This reduces the effective width of flow in the channel, and smaller LWD that otherwise might be flushed through the channel is deposited by racking up against the key member. Sequential deposition of racked normal and oblique members results in vertical stacking of five or more layers of debris. Sediment deposition occurs in the low-velocity zone in the lee of the jam, leading to floodplain formation and vegetation growth. Where wood supply is abundant, bar apex jams can grow rapidly in the upstream direction to more than double the length of the original key member.

Fuerstenberg et al. (1996) reported LWD loading volumes in natural river systems of 250 to 500 pieces per mile. The Green River load is only 27 pieces per mile, an order of magnitude lower than undisturbed streams, with most of it deciduous (Fuerstenberg et al. 1996). Recruitment rates are only about 600 cubic feet per mile per year compared with over 8,000 cubic feet per year for the Quinalt (Fuerstenberg et al. 1996). The major problems in the Green River are (1) the composition of the riparian zone and (2) ongoing removal of wood from the river for navigation purposes. There has been an overall decline in the channel complexity due to reduced recruitment and deposition of LWD.

2.3.7 Loss of Sediment Sources

Two historical changes in the watershed have substantially reduced the transport of sediment: the diversion of the White and Black Rivers out of the watershed in 1906 and the construction of HHD in 1962.

Gravel trapped behind HHD reduces spawning habitat and leads to channel downcutting. Within 55 percent of the watershed, a reduction of sediment has occurred since the implementation of HHD, which has severe implications for the Green/Duwamish Basin (Fuerstenberg et al. 1996). As a consequence of reduced sediment loads, the river channel in two reaches, the middle Green and the Duwamish, does not have the gravel and other materials to create new channels, point bars, estuarine delta, and other diverse channel features. Disruption of sediment transport from the upper watershed, due to the interception of almost all coarse sediment and gravel by HHD, may be causing fundamental changes in the mainstem channel and associated habitats, including the elimination of spawning gravels downstream of HHD. Perkins (2000) found that the average annual sediment inflow from the upper basin is 9,000 to 15,000 tons per year. Immediately below the dam, the river has the capacity to transport bedload sediment, but has no upstream sediment supply. Within a sediment starved system, the flow begins to scour the riverbed, entraining sediment and degrading the riverbed in a downstream direction. In the channel reach immediately below the dam, finer particle sizes have been preferentially removed, leaving the existing channel paved with sediment, which is much coarser than the pre-dam streambed (Perkins 2000). This effect is clear starting at the dam (RM 64.5), down to the upper end of the Green River Gorge (approximately RM 57). The active channel has narrowed by 29 percent; active storage sites have declined by 69 percent and are increasingly stabilized with vegetation (Fuerstenberg et al. 1996).

Downstream of the dam, erosion of the riverbed occurs since the system is sediment starved, causing the isolation of geomorphic features. Additionally, the main channel appears to be degrading below the side channel entrances, resulting in the isolation of side channels. High seasonal flows, intensified by urbanization and forest practices, have reduced the amount of vegetated surface, increasing the amount of excessive fine sediment inputs as a result of mass wasting from landslides. Furthermore, the diversion of the White and Black Rivers decreased the overall sediment input source. Overall, the river channel is downcutting, causing channel instability that is aggravated by the loss of riparian vegetation.

2.3.8 Increases in Water Temperatures

The loss of streamside vegetation and watershed forest cover has also resulted in an increase in the temperature of runoff entering the river and tributaries. This can lead to water temperatures in the river that are harmful and, in extreme cases, fatal to fish and other aquatic species, particularly in the late summer when flows are low.

Studies by the Muckleshoot Indian Tribe and King County suggest that elevated temperatures may be a significant problem in the lower Green River, with lack of large vegetation cited as a cause (Fuerstenberg et al. 1996). The height and density of the canopy is a factor in the production of shade, so trees will have to reach 100 to 200 feet to provide shading of the river. The maximum tree height today is 60 to 80 feet and shrub vegetation is a maximum of 20 feet high, while approximately 37 percent of the Green/Duwamish Basin consists of pavement which provides no shade.

Thicker canopies of conifers are more efficient traps of radiation than the thin canopies of hardwoods even though the densities may be the same (Fuerstenberg et al. 1996). Along the river’s edge, the low percentage of conifers contributes less thermal protection of the river. In addition, the temperature of effluent groundwater is a possible factor of temperature elevation in streams (due to the effect of elevated soil temperatures outside the buffer) (Fuerstenberg et al. 1996).

2.3.9 Changes in Flows

Large floods are generally responsible for creating the diverse habitats (gravel bars, backwaters, oxbows, sloughs) associated with large alluvial rivers such as the middle Green River. The absence of large floods has had a profound influence on habitat conditions in the unconfined portion of the mainstem in the middle Green River.

Inundation from the dam converts formerly free-flowing stream habitats to lake-like conditions during flood control operations and spring refill. The primary effects of inundation are a substantial reduction in vegetative cover, bank stability and the number and structure of pools, and an increase in the amount of fine sediment in riffles (Wunderlich and Toal 1992). The absence of large floods also reduces recharge of shallow alluvial aquifers that are an integral component of floodplain ecosystems (Naiman et al. 1992). During floods, water is stored in sloughs and side channels, or seeps into floodplain soils, recharging groundwater storage. This stored groundwater slowly drains back to the channel, providing a source of cool inflow during the summer (Naiman et al. 1992). For more detailed descriptions of alterations of river flows, please review the HHD Additional Water Storage Project Draft Feasibility Study and EIS (Corps 1998).

2.3.9.1 Low Summertime Flows

Flows in the mainstem of the Green River have always been very low in late summer, creating challenging conditions for resident fish and wildlife and early returns of salmon. Several changes in the watershed have aggravated this situation:

- timber harvest in the upper watershed has reduced groundwater recharge and summer discharges from groundwater to the streams;
- the loss of channel diversity due to flow controls has meant that low flows are spread across a broad uniform channel; and
- urban development and water withdrawals on tributaries have reduced groundwater discharges to the streams in these areas.

Low summer flows in the mainstem and tributaries hinder fish passage, increase predation of fish and other aquatic species, and contribute to high water temperatures. Low-flow releases from HHD during the summer conservation period are made through a 48-inch bypass intake located about 35 feet above the bottom of the pool. Low flows in the late summer frequently do not meet instream flow requirements, having only met flow requirements 9 out of the last 30 years (30 percent), thereby delaying upstream migration of adult chinook salmon (Fuerstenberg et al. 1996). Additionally, low summer flows adversely impact the amount of rearing habitat and exacerbate high summer water temperatures.

3 TARGET RESOURCES AND HABITATS

The Restoration Plan focuses on replacing components of the historic ecosystem whose absence limits fish and wildlife populations. The multi-species approach intends to restore ecological resources and processes that will benefit multiple fish, riparian, and riverine-associated wildlife species. This approach results in improving populations for a group of species, thereby resulting in improved populations of other species as part of a balanced natural ecosystem.

Multiple species and habitats will benefit from the restoration efforts by increasing the quantity and quality of habitat within the Green/Duwamish Watershed (i.e., increased amount of sediment for potential spawning habitat, increased LWD for shade and pool formation, riparian plantings for shade and future LWD recruitment, rearing habitat from estuary and wetland creation/connectivity, and refuge from side channel formation and floodplain connectivity). The approach focuses on implementing a balance of activities that will not be at the expense of maintaining or improving successful populations of any species within the Green/Duwamish Watershed. In particular, wildlife that utilizes the riparian zone will benefit from riparian vegetation plantings that provide protection and roosting or nesting habitat. Additionally, amphibians, such as the roughskin newt, will benefit from wetland connectivity/creation and side channel construction that provide essential habitat.

The Environmental Restoration Study Team (ERST) have concluded that the restoration of estuaries, channel diversity, riparian and emergent vegetation, floodplains, wetlands, and intertidal marshes and sloughs will directly benefit key resources. For example, increased clean intertidal salmon habitat benefits juvenile salmonids as well as salmon food organisms, crabs, shellfish, juvenile flatfish, wading and shorebird use, and the overall health of the ecosystem. The following describes habitats that will benefit from restoration.

3.1 Estuarine Habitat

The Duwamish Estuary is the transition area between the marine environment and the freshwater spawning and rearing habitat of the Green River. Estuarine areas are critical habitats for salmonids and a host of associated species. Estuarine habitats provide the following important functions:

- support a diversity of species which interact in complex predator-prey relationships;
- serve as spawning and nursery grounds for many flatfish and shellfish;
- support many birds and juvenile fish because of rich food supply (insects, epibenthic organisms), intertidal areas, and diverse habitats;
- provide rearing and refuge areas for salmonids;
- provide a protected and food-rich environment for juvenile salmon growth;
- allow the transition for both juveniles and adults between fresh and salt water; and

- support a high diversity of bird species providing cover, nesting sites, and food.

3.2 Channel Diversity

Natural (unaltered) river systems include habitat complexity in channel systems that include LWD and pools and riffles having a variety of substrate conditions. Functions include:

- LWD provides structure to stream channels by promoting habitat complexity that allows multiple salmon species to coexist.
- LWD helps retain gravel for spawning habitat, provides long-term nutrient storage and substrate for aquatic invertebrates that are salmon prey, and provides refuge for fish and prey during high- and low-flow periods (Spence et al. 1996).
- LWD provides cover for salmon, influences water flow, allows for the storage and transport of sediment and fine organic debris (as well as salmon carcasses), and influences the physical structure and stability of important habitat features such as pools (Ralph et al. 1994, Spence et al. 1996).
- Gravel provides spawning material for salmonids to build redds.
- Excess sediment removal allows sufficient water/oxygen flow within the gravel for spawning habitat.
- Pools provide resting and holding habitat for upstream migrating adult salmon and allow swimming speeds needed to jump obstacles (Spence et al. 1996).

3.3 Streamside Vegetation (Riparian Corridor)

Streamside vegetation is an important component of a properly functioning riverine system and benefits a multitude of aquatic and terrestrial species. The benefits of streamside vegetation include:

- provide trees, snags and shrubs for nesting, roosting, feeding, and cover;
- provide large trees for future LWD or in-stream habitat;
- provide shade for temperature control;
- stabilize the bank from erosion by roots;
- filter out nutrients from upland sources; and
- provide protective pathways for wildlife.

3.4 Floodplains/Wetlands

Floodplains and wetlands provide important habitat complexity in river systems and the following benefits:

- provide regulation of stream flow, stormwater storage, filter and cycle nutrients;
- provide rearing and over-wintering areas for a variety of fish species including salmonids;
- provide overbank storage thereby increasing riparian growth rate and survival;
- provide refuge and rearing habitat; and
- improve riverine processes to allow passage, foraging, and reproduction.

3.5 Effectiveness of Integrated Ecosystem Restoration

Klimas (2000) conceptually evaluated the effectiveness of Green/Duwamish River restoration in achieving an improved and functioning ecosystem. The focus of the analysis was on the interrelationships among the component elements and their cumulative and synergistic effects in accomplishing overall ecosystem restoration.

Klimas (2000) evaluated three functions; nutrient interactions, habitat structure, and lateral connectivity, using the following assumptions:

Nutrient Interactions – employs indicators of production, transfer, and storage of organic material

- As forests mature and contribute woody debris to the system, the function of the constructed log jams will be renewed and expanded. Wood recruitment will be increasingly more effective as trees become larger.
- Channel dynamics will recruit sediment to the system due to bank erosion. The degree to which this will offset sediment entrainment behind the upstream structures is uncertain. Channel movement and sediment redistribution will also create new sites for storage and processing of organic materials (bars, back-of-bar channels, wetlands, etc.).

Habitat Structure – indicated by construction and maintenance of structural features that are important habitat components, particularly for salmonids

- The beneficial effects of woody debris on pool and bar formation within the stream system will be gradually augmented as riparian forests mature.
- Steadily improved channel dynamics will recruit sediment and woody debris to the aquatic system, and thereby periodically create new colonization substrates for plants and resultant habitat diversity for terrestrial animals.

Lateral Connectivity – indicated by projects that provide continuity among different habitat types within a particular reach

- The principal effect of dynamic interactions will be to provide lateral connectivity by promoting the occurrence of various aquatic habitats (pools, bars, back-of-bar channels, wetlands) and diverse terrestrial systems (sequentially colonized bars) in close proximity within any particular reach. This will be particularly effective in river and tributary reaches where woody debris is capable of initiating bank erosion and recruitment of additional wood and sediment.

Given these factors, Klimas presented a graphic representation (Figure 3) illustrating the anticipated effectiveness of the proposed restoration activities considered in terms of spatial continuity from the estuary to the upper basin. The overall effect is that every reach is the object of some restoration activity, and the entire length of the river will improve in linear continuity at the completion of the 50-year planning period (Klimas 2000). Nutrient interactions are not expected to be quickly established by construction and planting, because the production component requires time to become effective. In contrast, the construction of habitat structure is more quickly established. The restoration of lateral connectivity will be accomplished rapidly for aquatic systems, and somewhat later for terrestrial systems (Klimas 2000).

4 PLANNING PROCESS, PROJECT EVALUATION AND SELECTION

The planning process used for this Green/Duwamish River Basin Restoration Plan is based on the Federal Water Resources Council's Principles and Guidelines.

A plan formulation strategy was developed by the Corps and King County based on the conclusions reached from the studies identified in Section 1. Plan formulation proceeded along four paths:

- developing prototypical designs and cost estimates for restoration projects based upon sites with adequate topographic information;
- obtaining local sponsor involvement in the solicitation of restoration project proposals from state and local agencies, Indian Tribes, and non-profit groups;
- developing a methodology for measuring environmental outputs associated with each of the proposed restoration projects; and
- conducting basin-wide analysis to identify processes and constraints currently affecting aquatic habitat and riparian areas.

4.1 Preferred Plan

The preferred plan will be a program to restore ecological resources and processes that will (1) benefit multiple fish, riparian, and riverine-associated wildlife species; (2) address the major watershed resource problems; and (3) meet the restoration goals.

The preferred plan will focus on implementing a balance of activities that will not be at the expense of maintaining or improving successful populations of other species. This approach assumes restoring larger areas of aquatic environment and riparian corridors, and providing connections to existing productive habitat. Implementing this approach will result in improved populations for a group of species, thereby resulting in improved populations of other species as part of a balanced natural ecosystem.

A combination of project activities will be implemented that will provide the most benefit to key species with the least environmental impact.

Under the plan, the geographic focus will be at the watershed level, with the intent to manage restoration based on the total resource need rather than through individual programs.

Examples of activities that might be conducted include:

- Reducing barriers to fish passage – This activity will include reconnecting old channels by removing or relocating levees and other barriers.

- Increasing salmonid habitat – This activity will include retaining or importing sediment and importing LWD in the mainstem, side channels and in tributaries.

- Increasing channel diversity – This activity will include improving the channel cross sections. Channel diversity will also be improved by connecting tributary flows into the mainstem and implementing channel-forming flows.

- Improving estuarine habitat – Habitat will be increased by creating deltaic habitat in saltwater areas.

- Increasing streamside vegetation – Streamside vegetation will be increased by planting along tributaries, side channels, and the mainstem.

- Increasing floodplains and wetlands – These areas will be increased through levee setbacks and removals, restoration and connection of wetlands, and connection of floodplains.

The plan will be implemented by the cities through the Green/Duwamish River Ecosystem Restoration Program administered jointly by the Corps of Engineers and King County. Monitoring of restorations and restoration success will be accomplished from a watershed (ecosystem) approach, utilizing the monitoring protocol and Geographic Information System (GIS) database program developed as a part of the ERS.

4.1.1 Best Management Practices

The construction of restoration projects will include the use of Best Management Practices (BMPs) to minimize the impact of construction activities. These BMPs are also defined for compliance under the Endangered Species Act (ESA). These BMPs include:

1. All regulatory permits and official project authorizations must be secured before project implementation. All terms and conditions in these regulatory permits and other official project authorizations must be followed to eliminate or reduce adverse impacts to any endangered, threatened, or sensitive species or their critical habitats.

2. Instream construction will occur only during approved in-water work windows.

3. Minimize the use of heavy equipment that will result in excessive soil disturbances or compaction of soils.

4. Use of heavy equipment in or adjacent to streambeds and streambanks must be minimized to reduce sedimentation rates, channel instability, and aquatic habitat impacts. If fording of equipment is absolutely necessary, vehicles and machinery will cross streams at right angles to the main channel whenever possible. Crossing sites will avoid sensitive fish habitat and areas susceptible to erosion, and they will be restored if necessary.

5. Excavation or transport equipment will be limited in capacity, but sufficiently sized to complete required restoration activities.

6. Streams, riparian zones, and wetlands will not be used as equipment staging or refueling areas. Equipment will be stored, serviced, and fueled at least 100 feet away from aquatic habitats or other sensitive areas.

7. Where possible, restoration activities involving excavation will take place in the dry season. Where new channels are excavated, the excavation will be isolated from surface waters then breached once work is completed.

8. Native vegetation will be planted on disturbed sites (including project site, disposal and staging areas, and access roads) when necessary to reduce soil erosion, establish cover, prevent invasive plant colonization, and provide shade.

9. Sedimentation and erosion controls (certified weed-free hay bales, silt fence, etc.) will be implemented on all project sites where restoration activities are implemented, materials or equipment are staged, or fill is placed to minimize the release of fines into the aquatic environment.

10. Excavated materials removed during the completion of a restoration activity will be disposed of properly.

11. Boulder, rock, and large woody debris materials used for restoration projects will not be removed from any streams.

12. Inspection will be performed within one year following project completion to ensure that restoration activities implemented at individual project sites do not create unintended consequences to fish, wildlife, and plant species and their critical habitats.

13. Restoration activities will take place when minimal consequence to fish, wildlife, and plant species occurs.

14. Any temporary access roads will be built to avoid impacts to fish, wildlife, wetlands, or other sensitive resources. Any temporary roads built will be obliterated and the area restored upon project completion.

15. Any gravels in the streambed will be sieved first to remove fines.

4.2 Project Evaluation

Candidate projects have been identified and evaluated by the ERST using project evaluation criteria (rationale for selecting the locations and types of restorations) based on the limiting factors discussed in Section 2.

The ERST (consisting of a panel of biologists and other technical staff from the Corps, King County, the Muckleshoot Indian Tribe, Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and the participating watershed cities) used the project selection criteria to evaluate the effectiveness of projects submitted by agencies and organizations in addressing limiting factors, scale, feasibility, and benefits to wildlife. A feasibility analysis of the top-rated projects was conducted after evaluation and ranking of projects. The feasibility analysis included biological considerations along with design, cost, permitting, access, and land purchase factors.

4.2.1 Candidate Projects

During the past two years, the ERST compiled a list of candidate restoration projects for the Green River. The projects are a combination of the sites received in the ERS process, unimplemented projects from a previous failed bond issue, and sites added by the Corps and County study team to ensure a good basin-wide and limiting factors-specific coverage.

In total, 50 projects were identified and located as follows (see Figures 4, 5, and 6):

- Lower Green River (RM 11 to RM 35) – 4 projects
- Middle Green River (RM 35 to HHD) – 35 projects
- Upper Green River (above HHD) – 10 projects

Project number 50 (Volunteer Revegetation) will occur throughout the basin as needed to enhance the corridor.

4.2.2 ERS Criteria for Project Evaluation

The evaluation of the 50 candidate projects was based on the evaluation criteria presented in Table 2. Each of the 50 projects was evaluated using the criteria, and an overall weighted score was calculated. An incremental cost analysis was also conducted, considering the scoring factors from Table 2. Table 3 presents the results of the evaluation of the candidate restoration projects. Future candidate projects will also be evaluated using the same procedure.

The technical team described earlier in Section 4.2 will be maintained during future study elements. Their roles will include:

- reranking or reevaluating projects if there are changes using established criteria;
- proposing the sequence of projects to be constructed and the priorities for construction; and
- helping to develop a monitoring plan, reviewing/evaluating the monitoring results, and making recommendations.

4.3 The Next Steps in the ERS Process

The next steps in the ERS process include the following:

- Land Ownership and Access: The ERST will pursue approvals of land ownership and access to those sites on private property. The team will provide the landowners with all of the documentation needed to negotiate approvals for projects on private land.

- Project Construction: Assuming both the federal government and the relevant local sponsors authorize funds, project construction can commence as soon as the summer of 2001 for the early action projects. Projects going through the more traditional feasibility phase will likely begin construction in 2002.

Table 2. Evaluation Criteria for Alternative 2 - Multi-Species Approach, Green/Duwamish River Ecosystem Restoration Study

Evaluation Criteria	Proposed Project
<u>Limiting Factors:</u> ***How effective is the project at addressing one or more of the following limiting factors?*** (maximum 10 points) 1. Barriers to Fish Passage – Culverts, dams, and hatcheries 2. Reduction in Channel Forming Flows – loss of side channels and floodplain connections 3. Loss of Channel Diversity in Lower River – Levee and infrastructure have eliminated habitat 4. Loss of Estuarine Habitat – Filling for navigation and development has reduced the size of the estuary 5. Loss of Floodplain Habitat – Development and changes in flows have reduced floodplains connections 6. Reduction in Large Woody Debris – Log jams are now uncommon 7. Loss of Sediment Sources – Dam and construction of levees in floodplain reduced gravels for spawning habitat and leads to channel downcutting 8. Increase in Water Temperatures – Summer temperatures are stressful to fish **<u>Scale:</u>** ***Project - How large (linear feet, area benefited) is the project?*** (maximum 3 points) ***Effect – How far-reaching (e.g, linear feet of tributary to become accessible for spawning/rearing, etc.) is the project's effect?*** (maximum 6 points) **<u>Feasibility:</u>** ***Technical - Does a reasonable restoration technique exist and is it widely accepted?*** (maximum 3 points) ***Political – Is the proposal socially and politically acceptable and likely to be widely supported?*** (maximum 3 points) **<u>Wildlife:</u>** ***Habitat - Does the project benefit wildlife?*** (maximum 3 points)	
Total Score* (maximum 28 points)	

*Scoring

Limiting Factors Effectiveness - 1 to 5 points (Low, Low/Medium, Medium/High, High) and weighted by doubling score

Scale Effect –1 to 3 points (Low, Medium, High) and weighted by doubling score

All Other Categories- 1 to 3 points (Low, Medium, High) and no weighting

Table 3. Evaluation of Candidate Restoration Projects for the Green/Duwamish River Ecosystem Restoration Study*

				Limiting Factors		Scale		Feasibility			
Project No.	Project Name	Project Location	Basin	Factors	Effect	Project	Effect	Technical	Political	Wildlife	Overall
1	Elliott Bay Nearshore	Seattle	E	4	M	M	M	H	H	L	19
2	Site 1, Duwamish	Seattle	E	3,4,8	H	M	H	M	H	M	26
3	Riverton Side Channel	Tukwila	E/LT	1,3,4,6,8	M	M	M	H	H	L	19
4	Codiga Farms	Duwamish	E	3,4,5	M/H	M	M/H	H	H	M	24
5	Black River	Renton	LT	3,6,8	L/M	L	L/M	H	M	M	15
6	Gilliam Cr	Tukwila	LT	1,6,8	M/H	M	M	H	H	L	20
7	Lower Springbrook	Renton	LT	3,6,8	M	H	H	H	M	M	22
8	U Springbrook Acq/Rest	Renton	LT	3,5,6,7,8	M	L	M	M	H	M	18
9	Mill Crk.East	Kent	LT	3,6,8	M	H	M	H	M	M	20
10	Garrison Cr	Kent	LT	3,6,7,8	M	H	M	H	H	M	21
11	Mullen Sl Nursery	Kent/KC	LT	3,5,6,8	M	M	M	H	H	L	19
12	Mulleen Slough Reach	Kent/KC	LT	3,5,6,8	M/H	M	M	M	L	H	18
13	MC Schuler Br.	Auburn/Kent	LT	3,5,6,8	M/H	M	M	M	L/M	H	18.5
14	MC Merlino	Auburn	LT	3,5,6,8	M/H	M	M	M	M	H	21
15	MC Wetland 5K	Auburn	LT	3,5,6,8	M/H	M	M	M	M	H	21
16	MC Goedeke	Auburn	LT	3,5,6,8	M/H	L/M	M	M	M	H	20.5
17	Green River Park	Kent	LG	3,5,6	M/H	M	M/H	M	M	M	22
18	Horsehead Bend Sd Ch	Kent	LG	2,3,6	M/H	M	M	H	M	M	21
19	NE Auburn Cr	Auburn	LT	3,6,8	M	M	M	H	H	M	18
20	Meridian Valley Creek	Kent	LT	3,6,8	M/H	H	M/H	H	L/M	H	25
21	Lk Meridian Outlet Reloc	Kent	LT	1,3,6,8	M/H	H	H	M	M	M	23
22	Olson Creek	Auburn	LT	1,3,6,8	L/M	L	L	M	M/H	M	14.5

				Limiting Factors		Scale		Feasibility			
Project No.	**Project Name**	**Project Location**	**Basin**	**Factors**	**Effect**	**Project**	**Effect**	**Technical**	**Political**	**Wildlife**	**Overall**
23	Riverside Estates Side Channel	Auburn	LG	2,3,6	M/H	M	M/H	H	L	L	21
24	Mainstem Maintenance	Multiple Locations	LG	3,6	M	H	H	H	M	M	22
25	Porter Levee	Upstrm of Hwy 18	MG	1,2,3,6	H	M/H	H	H	L	M	26
26	Kaech Levee	Upstrm of Hwy 18	MG	1,3,6	L/M	M	M	M	L/M	M	15.5
27	Ray Crk.Trib.	Upstrm of Hwy 18	MGT	3,5,6,8	M/L	H	M	H	L	M	17
28	Hamikami Levee	Upstrm of Hwy 18	MG	1,2,3,6	M	M	M	H	M	M	19
29	Turley Levee	Upstrm of Hwy 18	MG	1,2,3,6	H	M/H	H	H	L/M	M	26
30	Loans Levee	Upstrm of Hwy 18	MG	1,2,3,6	H	M/H	H	H	L/M	M	26
31	Burns Crk.	Upstrm of Hwy 18	MGT	3,5,6,8	M/L	M	L	H	M	M	15
32	Mainstem Large Woody Debris	Multiple Locations	MG	3,6	H	H	H	M	L	L	23
33	Gravel Replacement	Lg Seg of M'stem	MG	2,3,7	H	H	H	M	L	N/A	22
34	Fl Geyser Sd Chan	Fl Geyser Park	MG	2,3,6	M/H	H	H	H	M	H	25
35	Flaming Geyser Landslide	d/s Flaming Geyser Pk	MG	3,7	M/H	H	M/H	L	M	M	21
36	Newaukum Ck LWD	Enumclaw	MT	2,3,6,8	H	H	H	M	L/M	M	24.5
37	Big Spring Creek	Newaukum	MT	2,3,6,8	M/H	M	M	H	M	M	21
38	Brunner Slough	Kanasket Park	MG	1,2,3,6	M/H	H	M	H	L/M	H	23
39	Upper Grn.Rvr. Side Chnl.	KC	MG	3,6	M/H	M	M	M	M	L	19
40	Upper Grn Rvr Gravel	KC	UGR	2,3,7	H	H	H	M	L	N/A	23
41	Gale Cr Culvert	Above HH Dam	UT	1	H	L	H	H	H	L	23

				Limiting Factors		Scale		Feasibility			
Project No.	**Project Name**	**Project Location**	**Basin**	**Factors**	**Effect**	**Project**	**Effect**	**Technical**	**Political**	**Wildlife**	**Overall**
42	Boundary Crk	Above HHDam	UT	1	H	L	M	H	H	L	21
43	Sweeney Cr Culvert	Above HH Dam	UT	1	H	L	M	H	H	L	21
44	Olsen Cr Culvert	Above HH Dam	UT	1	H	L	L	H	H	L	20
45	May Cr Culvert	Above HH Dam	UT	1,8	H	L	L/M	H	H	L/M	21.5
46	Maywood Cr Culvert	Above HH Dam	UT	1,8	H	L	L/M	H	H	L/M	21.5
47	Gold Cr Culvert Retrofit	Above HH Dam	UT	1	H	L	M	H	H	L	22
48	Sunday Cr Rip. Plantings	Above HH Dam	UT	8	M/H	H	H/M	H	H	H	25
49	North East Cr Culvert	Above HH Dam	UT	1	H	M	M	L/M	H	L	21.5
50	Volunteer Reveg	Multiple Locations	MG	6,8	L/M	H	L	H	M	L	15

Legend:

E = estuary — H = high

LT = lower tributary — M = medium

LG = lower Green River — L = low

MG = middle Green River

UGR = upper Green River

UT = upper tributary

* See Table 2 for a description of the evaluation criteria.

5 DESCRIPTION OF SELECTED PROJECTS

This section describes the 50 specific projects compiled and evaluated by the ERST. The 50 projects will be located in the basin as described in Section 4.2; a matrix of the projects is presented in Appendix F.

A detailed description of selected projects is presented in the engineering feasibility report available from the Corps of Engineers. These detailed descriptions include the site location, site constraints/problems, project goals, proposed solutions, recommended plan, cost items and quantities, conclusions and recommendations, references, and 35% design drawings.

5.1 Elliott Bay Nearshore

5.1.1 Project Location

This project is located at the 30-foot contour northeast of Duwamish Head in Elliott Bay.

5.1.2 Project Goal

Provide additional primary productivity in the nearshore area and a hard substrate for macroalgae attachment, thereby providing a more complex nearshore environment as refuge for juvenile salmon and young rockfish.

5.1.3 Project Description

The project will enhance the substrate by placing angular rock at the 30-foot contour. Shell hash and pea gravel will also be placed at the minus 2-foot contour. A pilot study was conducted using this methodology, yielding positive results of large macroalgae attachment and use by various marine organisms. Rocks will be sieved to remove fines prior to placement.

5.2 Site 1, Duwamish

5.2.1 Project Location

The project lies on the east bank of the Duwamish River just north of South 112th Street in the City of Tukwila.

5.2.2 Project Goal

Restore estuarine habitat within the lower Green/Duwamish River, thereby improving off-channel intertidal marsh habitat for early marine juvenile salmonids.

5.2.3 Project Description

Historically, the lower Green/Duwamish River was an expansive estuary. Over time, the intertidal areas have been filled, tributaries were piped and/or made inaccessible, and the channel was straightened and dredged. The project entails excavating fill and native soils to a depth of 2 feet MLLW at the inlet to 12 feet MLLW at the upper edge of the estuarine marsh, thereby creating an off-channel, emergent marsh and intertidal habitat. Construction will include adding riparian and emergent vegetation and LWD to create higher quality intertidal habitat.

5.3 Riverton Side Channel

5.3.1 Project Location

This project is located in the City of Tukwila, immediately north and east of the intersection of State Route (SR) 99 and SR 599. The reach extends from the Green River, upstream to where the stream crosses underneath SR 599.

5.3.2 Project Goal

Improve the connection between Riverton Creek and the Duwamish River, thereby restoring a more natural tidal connection, and providing summer rearing, winter rearing, and flood refuge habitat.

5.3.3 Project Description

Riverton Creek has been channelized and relocated through time. The lower reach has been separated from the Green/Duwamish by a set of culverts with flapgates, severely restricting fish access and tidal influence on the creek. The flapgates will be removed and replaced with "Waterman Self Regulating Tidegates," which allow normal tidal flushing to occur in the creek. The channel, which will connect with the river on the downstream end, but not the upstream end, will be a backwater slough providing winter rearing and flood refuge habitat. Construction will include establishment of LWD. Loss of existing wood will be minimized. The existing tide gate will be replaced with a passable gate. Invasive plants will be removed and replanted with native trees and shrubs.

5.4 Codiga Farms

5.4.1 Project Location

This project is located in the City of Tukwila near 50th Place South and South 130th Place.

5.4.2 Project Goal

Restore tidal hydrology by creating a slough, which will provide rearing and feeding habitat for juvenile salmonids as well as providing an educational outreach to the public through the use of interpretation signs and observation areas.

5.4.3 Project Description

Historically, this portion of the Green/Duwamish River had a broad and connected floodplain with estuarine marshes and sloughs. Currently, the site is a farm and pea patch. The project will create off-channel habitat through excavation of two backwater channels to an elevation of +2 MLLW. Riparian and wetland plantings will take place. Unwanted vegetation will be removed prior to planting. Pool habitat will be created through excavation and LWD placement. LWD will be placed in front of excavated pools to add stream shade and structure. Large rocks will be placed to break up the flow within the backwater channel. Around the channel an observation platform will be constructed with interpretation signs.

5.5 Black River Marsh

5.5.1 Project Location

The project is located at the confluence of the Black River and the Green River in the City of Renton.

5.5.2 Project Goal

Provide an intertidal emergent marsh, thereby providing primary productivity/nutrient export, habitat connectivity with the riparian zone, and rearing and storm refuge habitat for salmonids.

5.5.3 Project Description

Historically, a large marsh was located at the confluence of the Black River and the Green/Duwamish River near the current Ft. Dent Park. Today, the area around Ft. Dent is fragmented with a quarry, railroads, water treatment facilities and roads. The project entails the excavation of 200 cubic yards of fill from the left bankline of the Black River at the confluence just south of the railroad tracks to an elevation of 10 MLLW. The restoration activities include riparian and wetland plantings, and LWD placement. Unwanted vegetation will be removed prior to planting. The riparian buffer will be planted from the railroad bridge to the confluence with the Green River. Wetland species will be planted to 12-foot elevation.

5.6 Gilliam Creek

5.6.1 Project Location

The project is located in the City of Tukwila on Gilliam Creek east of the I-5/I-405 interchange at Southcenter. The project extends from the confluence of Gilliam Creek and the Green River, upstream approximately 2,000 feet to the Southcenter Mall entrance along Gilliam Creek.

5.6.2 Project Goal

Provide fish passage, improve salmonid winter rearing and spawning habitat, while maintaining current flood level protection.

5.6.3 Project Description

The Green River is tidally influenced at this location. A flap gate at the confluence of Gilliam Creek and the Green River prohibits fish passage and access to upstream habitat. Existing upstream habitat lacks in-channel structure and pools. The area is prone to urban flooding, as much of the upstream catchment is suburban development land use. Most of the reach is likely to be depositional.

The project will improve passage by replacing the existing flap gate with a Waterman gate. Rearing habitat will be improved by pulling back the north bank as far as space (I-405 right-of-way) permits. LWD wads will be placed. Sinuosity may be added if settling velocities permit. Spawning habitat will be improved by adding one to three gravel pads in the potential spawning reach.

5.7 Lower Springbrook Creek

5.7.1 Project Location

The project is located on Springbrook Creek in the City of Renton. The reach extends from SR 167 to upstream of the Black River Pump Station.

5.7.2 Project Goal

Create rearing and storm refuge habitat for salmonids.

5.7.3 Project Description

Lower Springbrook Creek currently is lacking riparian vegetation and LWD. The project includes two-stage rechanneling, riparian planting, LWD placement, and dendrite and hummock construction. (A dendrite is a small tributary that enters the mainstem at an angle.) The reach between SW 16th Street and SW 23rd Street will be rechanneled, as will the west side of the reach between SW 34th and SW 40th. Riparian plantings will take place within a 30-foot buffer. Unwanted vegetation will be removed prior to planting. Pool habitat will be created through excavation and LWD placement. Dendrites will be created and excavated material used to form hummocks to provide increased riparian topography.

5.8 Upper Springbrook Creek

5.8.1 Project Location

The project is located on Springbrook Creek in the City of Renton. The upstream boundary of the reach begins where the creek crosses from the south to the north side of South 55th Street. The reach continues west along the north side of South 55th Street until it reaches the SR 167 east right-of-way.

5.8.2 Project Goals

Create a natural habitat for spawning, rearing, and storm refuge. Find an effective means of sediment removal while creating minimal disturbance to the creek.

5.8.3 Project Description

The Springbrook Reach currently is lacking in riparian vegetation and LWD. The project includes meandering the channel, placement of spawning gravel, sediment trap installation, placement of LWD, and riparian planting. The stream will be shifted to the north and gently meandered, maintaining one-stage stream configuration. Spawning gravel will be placed in the streambed. A sediment trap will be installed at the north end of the reach on one side of the channel, with riparian plantings on the opposite side. A 100-foot corridor of riparian plantings will occur along existing and proposed channels. Approximately five pools with LWD will be placed.

5.9 Mill Creek East

5.9.1 Project Location

The project encompasses four project sites located in the City of Kent. The Memorial Park site is located north of James Street and west of Jason Avenue/88th Avenue South. The SR 167 site is adjacent to SR 167, west of East Valley Highway/84th Avenue, south and north of Novac Lane. The 76th Avenue South site is located between 76th Avenue South and 72nd Avenue South. The South 212th site is located north of South 212th Street and west of 77th Avenue South.

5.9.2 Project Goal

Create a natural habitat for spawning, rearing, and refuge.

5.9.3 Project Description

The proposed action will excavate excess sediment, constructing a new low flow channel. Riparian vegetation will be planted after removing non-native, invasive plant species to provide habitat. Plantings will include a combination of native shrubs, conifers, and deciduous trees. LWD will be placed within the stream channel, thereby providing in-stream cover and increasing habitat complexity.

Figure 7 shows the location of the project and provides examples of LWD placement, deflector logs, and riparian plantings (willow stakes).

5.10 Garrison Creek (1)

5.10.1 Project Location

The project encompasses four project sites located in the City of Kent. The South 218th wetland site is located north and south of South 218th Street in the adjoining wetlands and forested wetlands. The Southeast 216th Street slide stabilization project site is located south of Southeast 216th Street and east of 100th Avenue Southeast. The Middle Fork sediment removal/channel restoration site is located in an area delineated by Southeast 216th Street on the north side, South 222nd Street on the south side, 94th Avenue South on the west side, and 100th Avenue Southeast on the east side. The SR 167 site is adjacent to SR 167 under the northbound off-ramp to South 212th Street.

5.10.2 Project Goal

Create a natural habitat for spawning, rearing, and refuge. Control sediment delivery from the landslide.

5.10.3 Project Description

Garrison Creek has been heavily impacted by a landslide located south of Southeast 216th Street and east of 100th Avenue Southeast, as well as by increased flows and sedimentation resulting from urban development. The proposed action will excavate excess sediment, constructing a new low flow channel. The project will replace the existing culvert with a three-sided box culvert to allow fish passage. Riparian vegetation will be planted after removing non-native, invasive plant species to provide habitat. Plantings will take place within the landslide area to minimize sediment delivery. Plantings will include a combination of native shrubs, conifers, and deciduous trees. LWD will be placed within the stream channel, thereby providing in-stream cover and increasing habitat complexity.

5.11 Mullen Slough, Prentice Nursery Reach

5.11.1 Project Location

This project is located at the Green River and extends upstream approximately 500 feet to include the nursery. Highway 516 crosses Mullen Slough within this site.

5.11.2 Project Goal

Create rearing and storm refuge habitat for salmonids.

5.11.3 Project Description

Fish passage from the main river to the nursery site is presently hindered during summer low flow by a steep channel slope. The proposed action will excavate the channel from its confluence with the Green River to about 500 feet upstream, creating a steady 2 percent gradient. The channel will be cleared of debris and blackberry bushes and the riparian zone will be planted with trees and shrubs to provide shade and bank stability. LWD will be placed in front of excavated pools to add stream shade and structure. Two dendrites will be constructed as additional refuge habitat. They will be 4 feet in width at the main channel and meander along the natural slope, narrowing gradually and ending at ground elevation. Hummocks will be formed with cut material from dendrite construction.

5.12 Mullen Slough Reach

5.12.1 Project Location

Mullen Slough is located in the City of Kent, approximately 2 river miles downstream on the Green River from its confluence with Mill Creek. Mullen Slough extends south from the Green River to 277th Street.

5.12.2 Project Goal

Create rearing and storm refuge habitat for salmonids.

5.12.3 Project Description

Today, Mullen Slough lacks pools and channel structure, hindering the slough from functioning effectively as rearing habitat and storm refuge. The project activities include channel meandering, LWD placement, and riparian plantings. The channel will be gently meandered from 277th Street to the beginning of the tree canopy. LWD pools will be created approximately every 50 feet. Riparian vegetation will be planted from 277th Street to the beginning of the tree canopy. Removal of reed canary grass, blackberry, and purple loosestrife will occur within a 100-foot buffer of the channel prior to planting. Plantings will include a combination of native shrubs, conifers, and deciduous trees.

5.13 Mill Creek, Schuler Brothers Reach

5.13.1 Project Location

The Schuler Brothers Reach is located on Mill Creek at the border of the cities of Kent and Auburn. The upstream boundary of the reach begins where Mill Creek crosses from east to the west side of SR 167. It meanders north through the Schuler brothers' property and crosses South 277th Street.

5.13.2 Project Goal

Create a natural habitat for rearing and storm refuge while increasing the reach's high flow hydraulic capacity.

5.13.3 Project Description

Today, Mill Creek is a straight, shallow stream channel lacking riparian plantings, hindering the creek from functioning effectively as rearing habitat and storm refuge. The project includes channelization, riparian planting, and dendrite construction. A two-stage rechanneling will create a meandering narrow segment bypassing the existing pond just south of South 277th Street. A two-stage channel will be created in the remainder of the reach to provide additional conveyance during high flows. Existing channel meandering will be left as is. Riparian vegetation will be planted (and unwanted vegetation removed) along existing and proposed channels. LWD pools will be created. Dendrites will be created and excavated material used to form hummocks to provide increased riparian topography.

5.14 Mill Creek, Merlino Reach

5.14.1 Project Location

The Merlino Reach is located on Mill Creek in the City of Auburn linking the Wetland 5K Reach and the Schuler Brothers Reach. It includes a portion of Mill Creek east of SR 167 to the south edge of the Schuler property.

5.14.2 Project Goal

Create rearing and storm refuge habitat within the reach for salmonids.

5.14.3 Project Description

Today, a lack of stream structure and riparian vegetation hinders the Merlino Reach from functioning effectively as rearing habitat and storm refuge. The project includes deepening, widening, and meandering of the channel, riparian planting, woody debris pool placement, and creation of dendrites and hummocks. A one-stage channel will be constructed south of 37th Street NW and a two-stage channel north of 37th Street NW. The existing stream will be deepened, widened, and meandered. Riparian planting of trees and shrubs will occur adjacent to any newly constructed channel. Unwanted vegetation will be removed prior to planting. Pools will be excavated and LWD placed every 50 feet. Dendrites will be constructed and excavated material used to create hummocks within the riparian buffer.

5.15 Mill Creek, Wetland 5K Reach

5.15.1 Project Location

The Wetland 5K Reach is located on Mill Creek in the City of Auburn. It extends from Main Street to the crossing of SR 167.

5.15.2 Project Goals

Create rearing and storm refuge habitat for salmonids.

5.15.3 Project Description

A straight, shallow stream channel and a lack of riparian vegetation hinder the Wetland 5K Reach from functioning effectively as rearing habitat and storm refuge. The channel will be gently meandered, maintaining a one-stage stream configuration. The riparian buffer will be planted according to the King County Flood Control Plan. Pool habitat will be created through excavation and LWD placement. Dendrites will be created and excavated material used to form hummocks to provide increased riparian topography.

5.16 Mill Creek, Goedeke Reach

5.16.1 Project Location

The project is located on Mill Creek in the City of Auburn. The Goedeke Reach is at the south end of Mill Creek west of SR 167. The reach is between SR 18 and Main Street.

5.16.2 Project Goal

Create rearing and storm refuge habitat and eliminate fish stranding in the north end pond.

5.16.3 Project Description

The existing channel is straight and shallow and lacks riparian vegetation. A disconnected pond at the north end of the site is a likely location for fish stranding. The project will widen the existing 5- to 6-foot channel to 8 to 10 feet. The channel will be deepened and meandered. The pond will be deepened to the water table (about 3 feet). A narrow connection will be excavated while minimizing riparian destruction. An additional 2-acre rearing and storm refuge pond will be constructed. Riparian plantings will take place within a 200-foot buffer of an 800-foot-long corridor and along newly constructed channel. Unwanted vegetation will be removed prior to planting. Pool habitat will be created through excavation and LWD placement. Dendrites will be created and excavated material used to form hummocks to provide increased riparian topography.

5.17 Green River Park

5.17.1 Project Location

The project is located in the City of Kent along the Green River at Green River Park.

5.17.2 Project Goal

Provide summer rearing habitat at the mouth and establish a backwater channel refuge for salmonids during high/flood flows in the mainstem of the Green/Duwamish River.

5.17.3 Project Description

Green River Park is an open, undeveloped park owned by the City of Kent along the Green River. The river has lost most of its off-channel habitat in this area through flood control and channelization. The project will create off-channel habitat through excavation of an off-channel slough. The bottom of the slough will be set at mean winter flow elevation. The slough will connect to the mainstem with a wide mouth to avoid sedimentation and make it easy to find for fish during high flows. Inner slough erosion will be minimized after construction. LWD will be placed in the channel initially, on a short-term basis. Riparian areas will be planted.

5.18 Horsehead Bend Side Channel

5.18.1 Project Location

The project is located in the City of Kent east of Central Avenue South and west of the intersection of 94th Place South and Green River Road at RM 26, on a tight meander just upstream of the completely leveed portion of the Green River.

5.18.2 Project Goal

Provide summer rearing and flood refuge habitat for salmonids.

5.18.3 Project Description

Horsehead Bend is a meander bend that has been locked into place by a right bank levee since 1965. The project will excavate a channel in the narrow peninsula on the south side of Horsehead Bend (on the inside of the bend). The channel, which will connect with the river on the downstream end, but not the upstream end, will be a backwater slough providing summer rearing and flood refuge habitat (Perkins 1998a). The channel will be approximately 950 linear feet in length and will follow the old channel, terminating at a depression located on the east side of the terrace. Figure 8 shows the location of this project and presents an example of side channel excavation.

5.19 NE Auburn Creek

5.19.1 Project Location

The project is located in the City of Auburn. It begins at the confluence of NE Auburn Creek and the Green River at approximately RM 25.9 and extends upstream to the culvert at SE 277th Street.

5.19.2 Project Goal

Provide adult and juvenile passage to winter refugia, foraging, and summer rearing habitat in NE Auburn Creek.

5.19.3 Project Description

A large tide gate currently blocks passage for fish into Auburn Creek at its confluence with the Green River. The creek currently has approximately 2,000 feet of cottonwood riparian canopy upstream from the tide gate. Beyond this, the creek turns into a ditch with little or no riparian vegetation other than blackberry. The project will remove the existing tide gate and install a hollow girder concrete bridge to allow fish passage into the creek. LWD will be added to the existing channel and riparian vegetation will be rehabilitated where it is currently lacking.

5.20 Meridian Valley Creek

5.20.1 Project Location

The project is located in the City of Kent on Meridian Valley Creek. The project extends from under SE 256th Street to the confluence with Soos Creek.

5.20.2 Project Goal

Provide fish passage, improve upstream habitat, and provide hydraulic connection between Soos Creek and existing wetlands.

5.20.3 Project Description

A 1,000-foot-long, rectangular, concrete flume has a deposition problem at its downstream end, limiting the ability for fish passage to upstream habitat. Other habitat limitations include lack of riparian vegetation along the flume, in-stream cover, and off-channel refuge. The project will improve fish passage by abandoning the flume and constructing a new channel from SE 256th Street to Soos Creek. LWD will be placed and riparian vegetation will be planted.

5.21 Lake Meridian Outlet Relocation

5.21.1 Project Location

The project is located in the City of Kent extending from the outlet of Lake Meridian at Lake Meridian Park to the confluence with Soos Creek.

5.21.2 Project Goal

Establish a waterway between Soos Creek and Lake Meridian to provide salmonid rearing habitat and passage into Lake Meridian.

5.21.3 Project Description

Lake Meridian currently drains through a series of ditches to Soos Creek. The project will construct a channel between Soos Creek and Lake Meridian. Construction will minimize the loss of existing wood and add LWD to the constructed channel. Excavated material will be removed from the site. Vegetation will be planted along the newly constructed channel.

5.22 Olson Creek

5.22.1 Project Location

The project is located in the City of Auburn on Olson Creek. The project begins at the confluence of Olson Creek and the Green River and extends upstream 1,500 feet.

5.22.2 Project Goal

Provide summer rearing habitat for salmonids by enhancing tributary habitat.

5.22.3 Project Description

An upstream culvert has failed and erosion from the area has left pools filled with sediment, reducing the quality of salmonid habitat and the transport capacity in the reach. The proposed project will restore 1,500 feet of tributary channel habitat by excavating excessive quantities of material from the channel. The project will remove excess gravel load, install LWD, plant the riparian zone, and create a two-stage channel for low flow transport. Riparian plantings will take place within a 50-foot buffer on both sides of the channel. Unwanted vegetation will be removed prior to planting. LWD will be added to the existing channel. Coir fabric (similar to jute) will prevent erosion of the disturbed soil.

5.23 Riverside Estates Side Channel

5.23.1 Project Location

The project is located in the City of Auburn near 37th Street Northeast at RM 28.8 behind Reddington Levee.

5.23.2 Project Goal

Reestablish side channel habitat to provide summer rearing habitat and winter refugia while maintaining the existing level of flood protection.

5.23.3 Project Description

The project site is in an abandoned side channel between the existing levee and the Riverside Estates homes. The historical channel has a well-established cottonwood-dominated canopy. Through flood control and channelization, the mainstem Green River has lost most of its off-channel habitat. The proposed project will reestablish off-channel habitat through construction of a side channel. The channel will be excavated to groundwater elevation at summer low flow. The existing tide gate, which currently permits the side channel to drain after flooding (Perkins 1998b), will be replaced with a Waterman gate. Construction will include establishment of LWD in the new channel. Loss of existing wood will be minimized. Excavated material will be removed from the site. The proposed action will not increase flood elevations.

5.24 Mainstem Maintenance

5.24.1 Project Location

The project is located from the City of Auburn to the City of Tukwila.

5.24.2 Project Goal

Provide some in-channel habitat complexity in areas where few restoration options are available.

5.24.3 Project Description

The project will set back the levee to the edge (or near the edge) of the historical meander bend, remove the access road that crosses the meander bend, and excavate a downstream connection to the river. This will allow the river to reoccupy the meander bend. By allowing the river to reoccupy the historical meander bend, the channel may meander downstream, creating new bends in response to flow deflection in the first bend. The possible channel migration may create new side channels, providing an increased amount of winter and summer rearing habitat and spawning habitat. The project will set back levees as needed.

5.25 Porter Levee Setback

5.25.1 Project Location

The project is located southeast of the City of Auburn on the Green River, one mile upstream of the crossing of SR 18.

5.25.2 Project Goal

Allow the natural river meandering and habitat formation, including natural creation and maintenance of summer and winter rearing and refuge habitat, by purchasing and restoring former floodplain currently used for farmland.

5.25.3 Project Description

The Porter Levee currently limits places where the river is allowed to spill over its banks and recharge the adjacent floodplain. Much of the historic floodplain in this area has been lost to conversion to agriculture. A portion of the training levee was removed to reconnect the river to an old slough. This project will remove the remainder of the existing training levee. Approximately 1,800 linear feet of new levee will be constructed at Green River Valley Road. The removal of the levee will restore approximately 45 acres of floodplain to the area. Large woody debris will be placed in the floodplain and riparian planting will occur along the river as well. An additional 200-foot levee will be constructed on the up-river side of the property, adjacent to the river, to prevent flooding of neighboring property.

5.26 Kaech Levee Pond

5.26.1 Project Location

The project is located southeast of the City of Auburn just upstream of the Neely Bridge on the Green River.

5.26.2 Project Goal

Improve the pond outlet to improve accessibility and control the water level in the pond. Create rearing and storm refuge habitat and improve fish habitat.

5.26.3 Project Description

Kaech Pond currently is lacking in riparian vegetation and LWD. Riparian plantings will take place within a 50-foot buffer. Unwanted vegetation will be removed prior to planting. Pool habitat will be created through excavation and LWD placement. LWD will be placed in front of excavated pools to add stream shade and structure. The project will excavate a channel on the west side of Kaech Pond to improve accessibility to the pond.

5.27 Ray Creek Trib Corridor

5.27.1 Project Location

The project begins at the confluence of Ray Creek and the Green River at RM 34.2, immediately downstream of the Nealy Bridge, and extends 2.3 miles upstream.

5.27.2 Project Goal

Restore and protect a native coniferous plant community within the riparian buffer. Create natural habitat for spawning, rearing, and storm refuge.

5.27.3 Project Description

Today, the tributary lacks riparian vegetation and is readily accessible to livestock that have eroded much of the streambank. The project will include easements and fencing boundaries. Riparian plantings will take place within a 100-foot buffer width on both sides of the channel. Invasive vegetation will be removed and replaced with native riparian vegetation. The project will remove excess fine sediment where necessary.

5.28 Hamikami Levee Modification

5.28.1 Project Location

The project is located 3 or 4 miles southeast of the City of Auburn on the Green River.

5.28.2 Project Goal

Connect an existing forested wetland to the river, thereby providing overwintering fish habitat in the channel behind the Hamikami Levee.

5.28.3 Project Description

The channel behind the Hamikami Levee does not currently provide adequate overwintering habitat for salmon due to low water and lack of regular flow. The project will improve winter habitat by increasing the amount, duration, and quality of water in the old channel. The project will excavate three 175-foot-long access channels, providing access to the forested wetland. Riparian and wetland plantings will take place. Unwanted vegetation will be removed prior to planting.

5.29 Turley Levee Setback

5.29.1 Project Location

The Turley Levee is located on the Green River a few miles east of the City of Auburn just upstream of the Neely Bridge.

5.29.2 Project Goal

Create side channel habitat including salmonid wetland rearing and refuge habitat.

5.29.3 Project Description

The Turley Levee is the middle of a series of three discontinuous training levees built in the early 1960s to prevent the Green River from migrating north into farmland. The levee was built at the river's edge and a forested strip of lowland exists behind the levee that was previously occupied by side channels. The project will entail the construction of a side channel that will enter the Green River downstream. Riparian and wetland plantings will take place. Unwanted vegetation will be removed prior to planting.

5.30 Loans Levee Setback

5.30.1 Project Location

The project is located near Burns Creek at the downstream end of the most active channel migration zone of the middle Green River at approximately RM 38.

5.30.2 Project Goal

Restore the natural meandering process of the river and create increased side channel habitat.

5.30.3 Project Description

The Loans Levee is a training levee built in 1960 to prevent the Green River from migrating north into farmland. The levee has gradually dampened channel migration activity for about half a mile downstream, resulting in a straighter channel with no recent formation of side channels. The project will set back the levee to the edge (or near the edge) of the former meander bend, remove the access road that crosses the meander bend, and excavate a downstream connection to the river. This will allow the river to reoccupy the meander bend. New bends will also develop downstream in response to flow deflection in the first bend. The resumption of channel migration will create new side channels that will provide a mixture of winter rearing, summer rearing, and spawning habitat.

5.31 Burns Creek Restoration

5.31.1 Project Location

The project is located in Burns Creek, a tributary flowing into the Green River from the north, at RM 38 (at the upstream end of Loans Levee).

5.31.2 Project Goal

Reduce property damage associated with flooding and channel aggradation. Control sediment delivery from Bell Ravine to Burns Creek. Provide fish passage and improve upstream habitat.

5.31.3 Project Description

Two major landslides occurred in 1991 and 1995 in the Bell Ravine, a tributary to Burns Creek behind the Auburn Youth Resource House. Aggradation of the streambed of Burns Creek causes flooding of several areas upstream of the confluence with the Bell Ravine tributary. Riparian plantings will take place within the landslide area of Bell Creek Ravine to minimize sediment delivery. Unwanted vegetation will be removed prior to planting. The project will include fencing boundaries and LWD placings.

5.32 Middle Green River LWD

5.32.1 Project Location

The project area extends from above the City of Auburn (RM 32) to the downstream end of the Green River Gorge (RM 45).

5.32.2 Project Goal

Restore natural ecosystem processes of LWD recruitment, transport, and structure in the mainstem Green/Duwamish River thereby enhancing salmonid habitat by increasing pool, rearing, spawning, and migration habitat.

5.32.3 Project Description

Today, there is an absence of large wood in the river channel, which contributes to low channel complexity in the mainstem Green/Duwamish River. This absence has occurred due to the historical and ongoing timber harvest throughout the Green/Duwamish Watershed and the flow regulation from HHD which greatly altered flow patterns. The project will increase pool habitat by placing key members of LWD in the stream channel to form bar apex jams and meander jams. Additional large wood will be placed. Trees will be planted to provide a future source of naturally recruited wood. Engineered logjams will be constructed where there is a need to protect property or ensure human safety.

5.33 Middle Green River Gravel Replacement

5.33.1 Project Location

The project extends from the City of Tacoma water supply intake at approximately RM 61 downstream to Flaming Geyser State Park at approximately RM 45.

5.33.2 Project Goal

Prevent further fisheries habitat degradation and restore areas currently degraded as a result of the bedload blockage at HHD.

5.33.3 Project Description

HHD has blocked passage of bedload sediment from the upper Green/Duwamish River Basin to the channel downstream since 1961. Measurements of the sediment accumulation in HHD suggest that the average annual sediment inflow from the basin is 9,000 to 15,000 tons per year (Perkins 2000). The river is scouring the channel bed downstream of the dam because there is no upstream sediment supply. The project will enhance spawning habitat by placing 12,000 cubic yards of spawning gravel into the stream channel annually. The gravel will be placed in various locations within the middle Green/Duwamish River Basin. All gravel will be sieved to remove fines prior to placement.

5.34 Flaming Geyser Landslide

5.34.1 Project Location

The project is located downstream of the southwest corner of Flaming Geyser State Park at RM 42.6 to 43.0.

5.34.2 Project Goal

Reduce fine sediment input from landslide to river, protecting spawning gravel downstream.

5.34.3 Project Description

The Flaming Geyser Landslide is a large feature on the outside bank of a sharp meander in the Green River. It extends from the river to the top of the valley wall, about 360 feet above. It is a deep-seated, rotational slump that is probably centuries old. The rate and mode of sediment delivery from the landslide to the river have varied over time. Erosion of the landslide toe has decreased over the past four decades while, concurrently, sediment delivery from the upper portion of the landslide has increased. The vast majority of the sediment from the landslide now comes from an unstable ravine that drains one of three bowls (Bowl 1) in the upper landslide.

This proposed project calls for construction of a new river channel that will move the river several hundred feet from its existing location and away from the slide toe. The new channel will eliminate the cutting of the toe of the slide and allow the landslide to move and heal without affecting the existing river. Further information is needed before project specifications can be detailed.

5.35 Flaming Geyser Side Channel

5.35.1 Project Location

The project is located in the undeveloped east side of Flaming Geyser State Park at approximately RM 44.

5.35.2 Project Goal

Provide summer and winter rearing and flood refuge habitat in a newly constructed side channel to the Green River.

5.35.3 Project Description

The project will construct approximately 2,100 feet of new side channel between an existing side channel and the Green River. The existing side channel flows east to west. The upstream half of the existing side channel formed during the large 1959 flood. Now a narrow, shaded creek, it flows in a straight configuration next to the valley wall. The downstream half of the existing side channel occupies the old bed of a major braid channel that experienced channel shifting and braiding prior to flood control by HHD. It is presently relatively stable. The proposed new channel will start at the existing side channel about 200 feet from its downstream end. It will be excavated in a dry swale for 1,300 feet, then follow a small, seasonably dry channel that drains a wetland. Flow will be split between the newly constructed channel and the downstream end of the existing channel. Riparian and wetland plantings will take place. Unwanted vegetation will be removed prior to planting.

5.36 Newaukum Creek

5.36.1 Project Location

The project is located on Newaukum Creek, one of the major tributaries flowing into the middle reach of the Green River at approximately RM 40, in southeast King County, east of the City of Auburn.

5.36.2 Project Goal

Create a natural wetland habitat for rearing and refuge for juvenile salmonids. Provide LWD within the mid-lower sections of Newaukum Creek to provide in-stream habitat complexity.

5.36.3 Project Description

Newaukum Creek is deficient in LWD and riparian vegetation, especially within the lower 4 miles. The active removal of LWD over the past 50 years, coupled with the loss of the coniferous riparian buffer and associated potential recruitment of large trees/key pieces of wood with rootwads, have impacted natural stream processes and channel morphology. This project will enhance and expand the degraded plateau wetlands adjacent to Newaukum Creek by constructing wetlands, removing invasives, and planting native vegetation. The project includes planting existing plateau wetlands and riparian zone with a 100-foot buffer on both sides of the channel and fencing off access to the creek from livestock. Unwanted vegetation will be removed prior to planting. LWD will be added to the existing channel.

Figure 9 shows the location of this project and presents an example of LWD and boulder jam placement.

5.37 Big Spring Creek

5.37.1 Project Location

The project is located in Big Spring Creek, a tributary flowing into Newaukum Creek northwest of the City of Enumclaw.

5.37.2 Project Goal

Recreate wetlands and connect to the creek, thereby creating rearing and refuge habitat for juvenile salmonids.

5.37.3 Project Description

Big Spring Creek has been rerouted to roadside ditches with road fill that has affected the hydrologic connectivity and reduced flow attenuation. Additionally, much of the wetland area has been reduced in size through agricultural modification that has included filling, ditching, and draining. The project will construct approximately 3,700 feet of new stream channel with approximately 2,700 feet of easement, buffer planting, and fencing boundary. The reach at 244th Avenue Southeast will be rechanneled. Riparian plantings will take place within a 100-foot buffer width on both sides of the channel. Invasive vegetation will be removed and replaced with native riparian vegetation.

5.38 Brunner Slough

5.38.1 Project Location

The project is located approximately at RM 58, upstream of Kanasket and Palmer, in Brunner Slough.

5.38.2 Project Goal

Improve salmonid habitat in Brunner Slough.

5.38.3 Project Description

The project entails excavating the slough to receive groundwater flow from underlying gravels, combined with maintenance excavation of the slough outlet.

Brunner Slough is the remnant of a meander bend cut off by the river sometime before 1940. The slough appears to be fed by groundwater, with a low natural levee at its outlet that is probably overtopped by the river for a period of weeks to months in most winters. The summer flow of water in the slough is currently low to none. Salmon habitat will be improved by increasing the flow of water through the slough, particularly during the summer rearing season. This will be accomplished by excavating the slough to below the water table. Excavation will occur in the portion of the slough where gravel could be encountered, in the upstream portion of the slough. The wetland in the downstream portion of the slough may also need to be excavated in order to achieve continuous flow through the slough to the river. Frequent maintenance may be needed to remove sediment deposits near the outlet of the slough and keep water moving through year-round.

5.39 Upper Green River Side Channel Enhancement

5.39.1 Project Location

This project encompasses two sites. Site one is located on the Green River at RM 60, approximately 4.5 miles downstream of the HHD. Site two is located downstream of site one at RM 58.5.

5.39.2 Project Goal

Restore sediment supply and transport to the side channels and LWD recruitment, thereby providing spawning, summer and winter rearing, and migration habitat in a newly constructed side channel to the Green River.

5.39.3 Project Description

The upper Green/Duwamish River is sediment-limited due to the implementation of HHD. The natural recruitment of sediment is insufficient, resulting in an incised channel that has a substrate that is embedded and armored with an absence of gravels suitable for spawning. The project will construct pool/riffle habitat sequences to increase channel complexity, create spawning habitat, and enhance rearing habitat within the existing side channel. The side channel will connect with the river on the upstream and downstream ends. Construction will include establishment of LWD and spawning gravel in the new channel. Pool habitat will be created through excavation and LWD placement. Loss of existing wood will be minimized. Excavated material will be removed from the site. LWD placement will consist of bar apex jams and lateral jams. Riparian plantings will take place. Unwanted vegetation will be removed prior to planting.

5.40 Upper Green River Gravel Replacement

5.40.1 Project Location

The project extends from the Tacoma Diversion Dam to Flaming Geyser.

5.40.2 Project Goal

Prevent further fisheries habitat degradation and restore areas currently degraded as a result of the bedload blockage at HHD.

5.40.3 Project Description

HHD has blocked passage of bedload sediment from the upper Green/Duwamish Basin to the channel downstream since 1961. Measurements of the sediment accumulation in HHD suggest that the average annual sediment inflow from the basin is 9,000 to 15,000 tons per year (Perkins 2000). The river is scouring the channel bed downstream of the dam because there is no upstream sediment supply. The project will enhance spawning habitat by placing 12,000 cubic yards of spawning gravel into the stream channel.

5.41 Gale Creek

5.41.1 Project Location

Gale Creek is a tributary to the Green River at the Howard Hanson Reservoir. The project is located at the Road 5530 crossing of Gale Creek, approximately 3,100 feet upstream from the confluence with the Green River.

5.41.2 Project Goal

Restore fish passage to the upper reaches of Gale Creek and Boundary Creek. Eliminate the hydraulic constriction of the creek at the culvert.

5.41.3 Project Description

The existing pipe arch culvert is perched 2.4 feet and prevents fish passage. It is also believed to be undersized and causes the creek to overtop the road during high flows. The project will replace the culvert with a 40-foot span bridge located next to the existing culvert. The creek will be rerouted through the bridge with the natural channel gradient maintained. Spawning gravel will be placed upstream of the site.

5.42 Boundary Creek

5.42.1 Project Location

Boundary Creek is a tributary to Gale Creek north of the Howard Hanson Reservoir. The project is located at the Road 5530A, upstream of Boundary Creek's confluence with Gale Creek, which is approximately 5,000 feet upstream from Gale Creek's confluence with the Green River.

5.42.2 Project Goal

Restore fish passage to the upper reaches of Boundary Creek. Improve habitat upstream of the culvert.

5.42.3 Project Description

The existing pipe arch culvert is perched by approximately 1 foot and prevents fish passage. In addition, a high water diversion culvert to its west is also perched by about 3.5 feet. The project will replace the high water diversion culvert with a bottomless arch culvert of larger size (16-foot span and 8-foot rise). Spawning gravel will be placed for 100 feet upstream of the site.

5.43 Sweeney Creek

5.43.1 Project Location

Sweeney Creek flows into the Green River several miles upstream of the HHD. The culvert is located on Sweeney Creek at Road 3703 crossing, approximately 200 feet upstream of the confluence with the Green River.

5.43.2 Project Goal

Restore fish passage by eliminating perched culverts. Improve instream habitat upstream of the culvert.

5.43.3 Project Description

There are two culverts at the Road 3703 crossing. The 60-inch-diameter east culvert is perched 1.3 feet and does not allow fish passage; the 48-inch-diameter west culvert is perched 3.5 feet. The site has a history of flooding problems. The project will replace the existing culverts with a 30-foot span bridge. In order to minimize creek channel rerouting, the bridge will be placed over the existing 48-inch culvert. LWD will be placed in the channel for 100 feet upstream of the culvert.

5.44 Olsen Creek

5.44.1 Project Location

The project is located approximately 250 feet upstream of the confluence with the Green River on Road 3703 at milepost 23.5.

5.44.2 Project Goal

Restore fish passage into the upstream reaches of Olsen Creek and improve habitat upstream of the culvert.

5.44.3 Project Description

The existing 72-inch-diameter culvert is perched and prevents upstream fish passage. The existing culvert will be replaced with a bottomless arch culvert of a larger size. LWD and spawning gravel will be placed in the upstream reach for 100 feet upstream of the culvert to provide habitat-forming structures.

5.45 May Creek

5.45.1 Project Location

The project is located on May Creek at the Road 5530 crossing. It is in the upper basin approximately 6 to 7 miles upstream from Howard Hanson Reservoir. May Creek is tributary to the Green River and the culvert is approximately 3,100 feet upstream of the confluence with the Green River.

5.45.2 Project Goal

Restore fish passage into the upstream reaches of May Creek and improve habitat upstream of the culvert.

5.45.3 Project Description

The existing 48-inch-diameter culvert is perched by about 2 feet at the downstream end and prevents upstream fish passage. The existing culvert will be replaced with a bottomless arch culvert of a larger size. Riparian plantings will occur within the approximately 700-foot-wide Bonneville Power Administration corridor, 650 feet upstream of the culvert. LWD and spawning gravel will be placed in the upstream reach for 100 feet upstream of the culvert to provide habitat-forming structures.

5.46 Maywood Creek

5.46.1 Project Location

The project is located in the upper basin on Maywood Creek approximately 2,000 feet upstream from the confluence with the Green River on Road 5530.

5.46.2 Project Goal

Restore fish passage into the upstream reaches of Maywood Creek and improve habitat upstream of the culvert.

5.46.3 Project Description

The existing 48-inch-diameter culvert is perched 2.6 feet and prevents upstream fish passage. The existing culvert will be replaced with a bottomless culvert adjacent to the existing culvert. The creek channel will be rerouted through the new culvert with the natural channel gradient maintained. The upstream riparian corridor will be vegetated to provide shading. LWD and spawning gravel will be placed in the upstream reach to provide habitat-forming structures.

5.47 Gold Creek

5.47.1 Project Location

The project is located on Gold Creek in the upper basin. The culvert crosses under Road 3703 at milepost 24.75.

5.47.2 Project Goal

Restore fish passage and improve upstream habitat for salmonids.

5.47.3 Project Description

A perched, 84-inch, 80-foot-long culvert lies next to a concrete culvert of 54 inches diameter. The 84-inch culvert conveys most of the flow at the site. Fish cannot migrate upstream because the culvert is perched by about 8 inches. The stream upstream of the culvert will benefit from adding a diversity of biological structure. The culvert will be removed and replaced with a bottomless arch culvert with an 18-foot span and a 9-foot rise. LWD will be placed every 25 feet for 100 feet upstream of the culvert.

5.48 Sunday Creek Riparian Planting

5.48.1 Project Location

The project is located in the upper Green/Duwamish River Basin on Sunday Creek approximately 2.5 miles upstream of Lester. The project site begins near the Bonneville Power Administration power lines approximately 2.75 miles upstream of the Sunday Creek confluence. The project extends upstream for approximately 2.9 miles.

Figure 10 shows the location of this project and presents an example of riparian planting (upland and water fluctuation zones).

5.48.2 Project Goal

Reestablish riparian vegetation along the project corridor to enhance salmonid habitat.

5.48.3 Project Description

The vegetation along the project site has been removed to protect the existing power lines in the area. Riparian plantings consisting of small native shrubs and plants will take place within a 100-foot buffer width on both sides of the channel. Invasive vegetation will be removed and replaced with native riparian vegetation.

5.49 North East Creek

5.49.1 Project Location

The project is located in the upper basin on North East Creek approximately 225 feet upstream from the confluence with Snow Creek. The project is approximately 2 miles southwest of Stampede Pass.

5.49.2 Project Goal

Restore fish passage and improve upstream habitat for salmonids.

5.49.3 Project Description

A 48-foot-long pipe-arch culvert is currently perched 15 to 17 feet above the downstream pool, preventing fish passage to upstream habitat in North East Creek. The project will replace the culvert with a bridge at a location to the west of the existing culvert and divert the stream by meandering a bypass channel to the confluence with Snow Creek. LWD and spawning gravel will be placed upstream of the existing culvert.

5.50 Volunteer Revegetation

5.50.1 Project Location

The location of the proposed project is throughout the entire Green/Duwamish River Basin.

5.50.2 Project Goal

Enhance the riparian corridor to increase areas of fish and wildlife habitat by providing cover and other riparian functions such as nutrient input.

5.50.3 Project Description

The HHD, the construction of numerous levees, and urban developments have combined to reduce the riparian buffer along the Green/Duwamish River. Riprap or rock banks have been implemented to stabilize several sections of the river, but they do not provide much habitat value to resident and anadromous fish and wildlife. The project will include providing plants to volunteer groups involved in replanting riparian habitat along the mainstem Green/Duwamish River and its tributaries. Invasive vegetation will be removed and replaced with native riparian species. A river model will be made, with the help of King County and the Diking Improvement District, to ensure the placement and growth of bioengineered material do not jeopardize the existing flood control in the lower Green/Duwamish River Basin.

6 SITE DESIGN AND IMPLEMENTATION

There are a number of steps to restoration design and implementation. This plan is in draft form, subject to change and adjustment as a result of the NEPA EIS process, additional project-level information, Endangered Species Act (ESA) considerations, negotiations with landowners, and funding considerations. Additionally, the final planning and construction of the projects will extend over an 8- to 10-year timeframe for implementation.

The potential for hazardous waste will be evaluated on a project-by-project basis. Land use practices at each particular restoration site will be examined to determine if there is a reason to believe that potential contamination exists. If there is a potential, then the proper sampling and testing will be conducted to determine the type and extent of the contaminants. Once the testing results have been evaluated, the site will be cleaned up in compliance with pertinent regulations, or if the contamination is too severe, the project will be abandoned.

Prior to final design of the projects, the Corps of Engineers and King County will be contacting all land owners to discuss the proposed restoration projects on their land. Another important component of project implementation will be obtaining the necessary permits from the regulatory agencies.

6.1 Additional Project Information

Site-specific information and 35% level design plans have been developed for many of the 50 restoration projects. For those projects lacking site-specific information, it will be necessary to develop concept project plans. This will involve the development of site maps and topography through survey or existing site-specific information and the characterization of the existing conditions of the site such as road access, vegetation, presence and location of wetlands, threatened and endangered species habitat, and other sensitive areas.

The 35% level design information will be used to define locations of access roads to the sites, construction staging areas, and the locations of restoration elements. Once the location of project features are known, the detailed information will be used to define the “Area of Potential Effect” (APE) to conduct site-specific historic and archaeological surveys to satisfy historic preservation and NEPA requirements. More information on the permitting requirements is presented in Section 6.3.

6.2 Site Design

Additional site plans will be finalized by the Corps of Engineers based on input from agency coordination and the consultation process. Site design consists of design drawings showing detailed information on the various components for each project. Design drawings show existing and future site topography and site features, the extent of construction, cut and fill, and detailed locations and types of restoration improvements such as construction of a side channel, daylighting and realignment of a creek, placement of LWD and boulders, and the type/quantity/location of vegetation planting. Project descriptions from King County utilized information provided from Perkins (2000) to determine LWD and sediment additions within the Green/Duwamish Watershed.

The design drawings will be accompanied by detailed specifications that define the requirements of each step in the construction process, and specify the quantities of earthwork, materials such as logs and stumps (LWD), the species and quantity of plants, and other items. Additionally, as part of the final site design process, temporary erosion and sediment control plans will be developed to minimize impacts to the area.

6.3 Permitting and Compliance

The sequence of permit and compliance activities is presented in Table 4. The permitting activities will run concurrently with the site design activities defined previously in Section 6.2.

Because the site-specific NEPA/SEPA process will tier to the programmatic NEPA/SEPA EIS, the approval process could be reduced to the minimum timeframe required by law. The information used for the NEPA EA/SEPA Checklist will be that collected during the conceptual planning phase and the site-specific design phase.

6.3.1 Programmatic Biological Assessment

Section 7(a)(1) of the ESA as amended (16 USC 1531 et. seq.) requires federal agencies to conserve endangered and threatened species. Section 7(a)(2) requires consultations to ensure that any action authorized, funded, or carried out by a federal agency is not likely to jeopardize the continued existence of listed, proposed, or candidate species or result in the destruction or adverse modification of critical habitats. Section 7(c) requires that a biological assessment (BA) be prepared for major construction projects if any of those species or their critical habitats are present in the proposed action area.

A programmatic BA was prepared to evaluate the Green/Duwamish River Basin Restoration Program under the requirements of Section 7 of the ESA. Rather than specifically evaluating the 50 projects currently envisioned in the Restoration Plan, the BA evaluates the types of activities that could occur in restoring fisheries habitat in the basin (e.g., culvert replacement, levee setbacks, channel construction, intertidal habitat modification, gravel supplementation, etc.). The BA evaluates each type of activity by developing existing conditions and determining potential effects on listed wildlife, plants, and chinook salmon and bull trout (see Section 8.0 of this plan for a summary of threatened and endangered species information for the project area). The effects of the restoration techniques were evaluated to determine results of restoration efforts for all aspects of salmonid habitat in the basin (water quality, habitat access, habitat structural elements, channel and floodplain condition and dynamics, flow and hydrology, riparian conditions, etc.). This approach will allow the Corps to tier the analysis of future restoration projects with similar activities to the programmatic BA and facilitate expedited ESA Section 7 consultation.

Table 4. Sequencing of Permit and Compliance Activities

Activity	Applicability	Agency	Duration
1. Negotiation with property owner	Following appropriate site selection	Local jurisdiction	Indefinite
2. Pre-meetings with local governments	Following appropriate site selection	Planning/Zoning and Shoreline offices	Indefinite
3. Local zoning and environmental review	Upon submission of zoning application and SEPA checklist	King County Planning/Zoning, Ecology	1 to 12 months (realistic timeframe is 4 months)
4. Shoreline substantial development application	If project located adjacent to state waters	Local/Ecology	30 days
4a. NEPA Environmental Assessment for individual projects	Project-specific NEPA compliance	U.S. Army Corps of Engineers	4 months
4b. SEPA checklist (adopt NEPA EA for SEPA compliance)	Project-specific SEPA compliance	King County Department of Natural Resources	
5. Grading and excavation permit application; local approval; sensitive and/or critical area ordinance	Disturbance of 50 of more cubic yards of soil or clearance of vegetation	King County and local municipalities	1 to 2 months
6. Pre-meetings with state and federal agencies	Following site selection and local pre-meetings	Various state/federal	Indefinite
7. Aquatic access application	If project involves state-owned aquatic lands	WDNR	Indefinite
8. Hydraulic project approval	Effect or impact within ordinary high water mark of state waters	WDFW	1 to 2 months
9. NPDES application	Potential to discharge storm or surface runoff; at least 5 acres of disturbance	Ecology	1 to 3 months

Activity	Applicability	Agency	Duration
10. Short-term modification of water quality permit application	Potential to affect quality of state waters	Ecology	1 to 2 months
11. Forest Practices Act Permit application	Timber removal near state waters	WDNR	1 month
12. Corps Section 404 Permit	Dredge or fill in U.S. waters	Corps	NWP: 1 month
13. Endangered Species Act coordination	Impacts on federally endangered species	NMFS, USFWS	Individual: 6 to 12 months Reevaluation of species presence prior to project implementation
14. Corps Section 10 Permit	Structures or excavation in U.S. waters	Corps/Ecology	NWP: 1month; Individual: 6 to 12 months
15. 401 Water Quality Certification	With Section 404/10 Permits	EPA	3 to 12 months
16. Tribal review	Potential to impact reserved treaty rights	Tribe	Indefinite

7 CULTURAL

Due to the unique nature of prehistoric and historic sites and Native American traditional cultural values, it is essential to consider cultural resources during the site selection phase. If significant historical or cultural resources are affected by the proposed project, it will be necessary to coordinate and possibly mitigate actions prior to initiation of ground-disturbing activities. Depending on the number and types of historical or cultural resources involved, this process can take several months and can add considerably to the project cost. In some cases, it may not be possible to mitigate for project impacts given the unique nature or significance of a particular historical or cultural resource site. In those instances, the Corps of Engineers and King County will abandon the site. Consideration of historical or cultural resources early in the site selection process is intended to prevent unnecessary expenditures of time and funding on sites where it will be prohibitively expensive or impossible to mitigate impacts to historical or cultural resources.

The Corps has drafted a Memorandum of Agreement among the Corps of Engineers, the Advisory Council on Historic Preservation, and the Washington State Office of Archaeology and Historic Preservation regarding the measures to be taken for the inventory, evaluation, and assessment of effects of restoration activities on historic properties (see Appendix E).

8 THREATENED AND ENDANGERED SPECIES

This section briefly summarizes the status of federal threatened and endangered species within the primary study areas.

In a letter dated January 13, 2000, the U.S. Fish and Wildlife Service (USFWS) provided a list of endangered, threatened, and candidate species that are known to occur or have the potential to occur periodically or occasionally in the vicinity of the primary study area (see Appendix C). In a letter dated June 22, 1999, the National Marine Fisheries Service (NMFS) also provided such a list (see Appendix C). These species include:

Species	**Status**
Gray Wolf	Endangered
Marsh Sandwort	Endangered
Grizzly Bear	Threatened
Marbled Murrelet	Threatened
Northern Spotted Owl	Threatened
Bald Eagle	Threatened
Puget Sound Chinook Salmon	Threatened
Bull Trout - Coastal-Puget Sound DPS	Threatened
Canada Lynx	Threatened
Coho – Puget Sound/Strait of Georgia ESU	Candidate
Mardon skipper	Candidate
Oregon Spotted Frog	Candidate

Although grizzly bear was not identified in the USFWS letter, it is also a threatened species with potential habitat in the Green River Basin. Suitable grizzly habitat exists and sightings have occurred near the project vicinity.

As stated earlier, biological assessments (BAs) have been prepared and submitted to the USFWS and NMFS for the restoration activities proposed in this plan. Approval of these BAs will likely allow the specific projects to be constructed unless any of the proposed activities deviates significantly from those defined in the programmatic BAs, or if previously unknown threatened or endangered species are found at the site during the site-specific field investigations. In such circumstances, it will be necessary to prepare a BA to cover that specific resource.

9 COORDINATION WITH OTHER PLANS

The intent of this Restoration Plan is to coordinate with other natural resource enhancement and preservation programs so that public investments under different programs can be focused in the same areas and can complement each other. Therefore, an important part of project planning is coordinating with other programs in the study areas related to site remediation, habitat enhancement, and compensatory mitigation. Because many regulatory agencies are participating on the ERST, a number of possible regulatory issues can be anticipated and discussed in advance. Both program-level interagency and locality-specific coordination will be conducted (see Section 6 of the EIS).

Several important habitat mitigation, enhancement, or restoration projects in the Green/Duwamish River Basin have either been implemented, are being implemented, or are well along in the planning stage. ERST intends to coordinate use of sites, avoid duplication of effort, resolve institutional issues, and coordinate the goals and design of the various restoration projects to maximize ecological benefit.

There are many federal, state, tribal, and local laws, regulations, and treaties potentially applicable to the ERS activities. Other Green/Duwamish River Basin area plans, policies, and programs instituted by those authorities may also need to be taken into consideration.

To construct a restoration project, various permits will be required from local, state, or federal agencies, and a public hearing may be required at the local level. Upon receipt of comments from the public, coordination between the various entities will begin. As permitting and funding are finalized, coordination between the entities will continue, thereby encouraging maximum ecological benefit.

9.1 Other Plans in the Green/Duwamish Basin

9.1.1 Green/Duwamish (WRIA 9) Steering Committee and Planning Process

In 1999, NMFS listed Puget Sound chinook salmon as threatened under the Endangered Species Act (ESA). Local and state governmental agencies in this region have been developing strategies to address the needs of this species through conservation planning, early action project implementation, and related measures. Within the Green/Duwamish Watershed, this has led to initiation of a conservation planning process for WRIA 9, which encompasses this watershed and several independent drainages that outlet directly to Puget Sound between South Seattle and Federal Way.

The Green/Duwamish Steering Committee oversees development of a plan that responds to salmon listings under ESA in the Green/Duwamish Watershed. It will identify, evaluate, and prioritize actions to protect and restore salmon populations, especially actions related to habitat.

This plan, which is expected to be completed around 2005, will evaluate a range of strategies to conserve salmonid habitat, including land use practices, policies and regulations, improvements to governmental programs such as roadway and levee maintenance, and acquisition and/or restoration of aquatic lands. This last item clearly overlaps the focus area of the ERS, and with many of the same participants involved in both projects, it is hoped that the ERS can serve as a significant restoration project development component of the WRIA 9 plan.

9.1.2 Tri-County ESA Response

The Tri-County ESA Response Effort is a voluntary assembly of local governments, Tribes, environmental coalitions, and business coalitions that have joined together for the common purpose of recovering salmon and responding to listings under the ESA. The goals of Tri-County Effort are to recover the Puget Sound chinook salmon and to accomplish recovery without undermining the economy of this metropolitan area. NMFS and the state share these goals.

Two objectives exist to obtain the desired goals:

- Implement an early action program to avoid impacts to chinook habitat in the freshwater and estuarine environments, to minimize unavoidable impacts to that habitat, to mitigate unavoidable impacts where necessary, and to protect and restore that habitat where practicable.

- Develop and implement long-term, science-based watershed plans for the conservation and restoration of aquatic ecosystems in each of the WRIAs.

9.2 NEPA Scoping Meeting

A combined NEPA/SEPA Environmental Impact Statement (EIS) has been prepared for this Restoration Plan (see Volume I). The EIS process will satisfy the requirements of the National and State Environmental Policy Acts. In the Notice of Intent, published by the Corps on December 23, 1998, the public was invited to provide written comments on the scope and content of the Restoration Plan/EIS, ask questions about the EIS, request to be included on the EIS mailing list, and request copies of any documents associated with the draft Restoration Plan/EIS. Notice of the scoping meeting was published in the Seattle Times/Post Intelligencer on January 13, 1999 and the South County Journal on January 16, 1999. Additionally, notices of the meeting were sent to approximately 3,200 agencies, organizations, and individuals on the EIS mailing list. The comment period ended February 3, 1999, which was 43 days from initiation on December 23, 1998. The Corps and King County did not receive any written comments during this scoping period.

An open house/scoping meeting was held on January 20, 1999, to provide the public with an early opportunity to engage in discussions regarding the EIS and to provide oral and written comments. Thirty-one people participated in the scoping meeting. The primary issues of concern were identified as:

- Evaluate the increase of erosion and sedimentation along rivers and creeks in the Green/Duwamish River Watershed, especially with regard to property loss, contamination of water quality, and damage to salmon spawning grounds.

- Address alteration of wetlands and vegetation in the Green/Duwamish River Valley.

- Address the hazard created by LWD for boat and “floater” recreationists.
- Address the lack of recreational access to the Green/Duwamish River.
- Address environmental impacts.

10 MONITORING

Monitoring is an important element for the restoration activities. There are several reasons for monitoring to occur under this study, including improving the understanding of restoration methods to reduce uncertainty in planning such projects in the future, facilitating the use of adaptive management principles, and adding to the general knowledge base on restoration which includes public education.

This section does not contain the actual monitoring plan. Rather it outlines the approach that the monitoring plan will incorporate. A monitoring plan that will be approved by the technical committee for this study is expected to be completed just prior to construction of the first projects in about 2002.

Monitoring will occur on a site- (or project-) specific level as well as a river reach level and ecosystem (basin) level. To be meaningful, monitoring will be tied to the specific restoration goals of a particular project. Some larger scale monitoring will also be used to determine the cumulative effect of all the restoration projects by monitoring at an ecosystem (river basin) level. Because there is much emphasis on restoring riverine processes where possible, geomorphic evaluation will be part of the monitoring plan. Analysis of sediment distribution, river cross sections, flow depths, and aerial photos will be used to evaluate how successful the projects have been.

Three types of monitoring are proposed to answer the following questions:

- Implementation: Did we do what we said we will?
- Effectiveness: Did our actions have the desired effect?
- Validation: Were the assumptions that we made correct?

The steps that will be followed in developing a monitoring plan are described below.

10.1 Develop Specific Goals and Objectives

This will be done at a project level and basin level. Objectives for each individual project have already been established and the target resources of the entire program can be found in Section 3.

10.2 Develop Conceptual Model

A conceptual model was developed as a part of the Green/Duwamish River Basin General Investigation Ecosystem Restoration Study – Reconnaissance Phase (Corps 1997). This complex interaction of riverine processes helps conceptualize how restoration projects will interact with the environment.

10.3 Develop Performance Criteria

Criteria will be based on program and project objectives. Program objectives are discussed in Section 1. Specific project objectives have also been developed. As an example, at May Creek on the upper Green River, there is a perched culvert that limits fish passage upstream. The performance criteria for this project will be to document fish use (presence) above the culvert after it is repaired.

10.4 Choose Monitoring Methods

Examples of sampling methods under consideration include:

- Estuarine Habitat Assessment Protocol (Simenstad et al. 1991) will be used on restoration projects that occur in the estuary (such as Site 1 and Codiga Farm).
- For other projects, standard methods will be used to assess fish presence and use such as seining or electroshocking.
- Percent cover of vegetation and species will be documented.
- For invertebrate analysis, the assessment of biotic integrity will be used (Karr 1981).
- Physical data such as water quality will focus on dissolved oxygen, temperature, and sedimentation and be consistent with the "Standard Methods for Evaluating Water and Wastewater".
- Birds and other wildlife will also be evaluated, usually for presence/absence and perhaps some behavior and productivity at selected projects.

The scale of effect for restoration activities is also of interest. This will include both temporal and spatial scales. Important considerations besides the methodologies will be the timing, frequency, and duration of sampling. From a timing perspective, individual projects will be monitored over five years but not necessarily every year. A typical project will be monitored in years one, three, and five after construction. From a spatial perspective, projects will be monitored throughout the river basin.

To determine effects at an ecosystem scale, a variety of methods can be used. They include supporting (financing) a screw trap (this is a particular type of fish sampling) and analysis. In areas where LWD and gravel are placed, river cross sections will be evaluated at several locations over time. We will also like to support the U.S. Geological Survey in some of their long-term monitoring sites on the Green River.

10.5 Manage the Data and Report Results

The Corps will maintain a database on the results and issue a report every two years after monitoring has been initiated.

10.6 Feedback Mechanisms

Using the results obtained from monitoring and based on project objectives, there will be an opportunity to adaptively manage the restoration projects. For each project that is not achieving its potential, contingencies will be developed. These contingencies or remedies fall into three broad categories:

- No Action
- Maintenance (physical actions to move the program or project toward the desired objectives)
- Modification of project goals and objectives

References to help develop the final monitoring program include:

- Planning Aquatic Ecosystem Restoration Monitoring Programs, Ronald M. Thom et al., 1996, IWR Report 96-R-23
- Planning and Evaluating Restoration of Aquatic Habitat from an Ecological Perspective, David Yozzo et al., IWR report 96-EL-4 1996

Prior to initiating any fish monitoring, permits will be obtained from the appropriate resource agencies (USFWS, NMFS, WDFW).

11 STEWARDSHIP AND OUTREACH

Stewardship and outreach are intimately linked. Stewardship involves actively seeking funding and approval of projects, implementing projects, and monitoring and maintenance of projects where appropriate. Outreach educates the public of the projects and explains any opportunities for public support to the stewards.

11.1 Stewardship

Stewardship includes a range of activities from checking on a project site to visiting on a regular schedule to conduct monitoring and maintenance activities. The role of the steward is to help the restoration project meet or exceed the success goals over time. The most effective stewards visit often, know who to call if they spot problems, handle simple problems such as routine garbage or weed removal on their own, and join organized monitoring projects. Volunteer stewards need to be managed from a non-profit or governmental office to prevent gaps in stewardship and to assure the quality of the work. This does create some burden for ongoing funding of projects. Where volunteers and volunteer programs are not available, jurisdictions may need to use staff for stewardship work. Park personnel will often need to be retrained in best management practices for restoration projects.

Most restoration projects are not self-sustaining under 250 acres, and even projects of size need stewardship during the early plant-establishment years. Most plants need at least two years of watering while roots become established, and weed management is crucial for five to ten years while shade canopies become established. Projects in highly urbanized watersheds like the Green/Duwamish Basin will face a host of challenges from human impacts such as point and non-point pollution, development, vandalism, and theft. Damage from beavers, resident Canada geese, and other wildlife can also slow or eliminate plant establishment. Stewardship is needed to minimize all of these ongoing impacts.

There are many local groups who can manage volunteer stewards in WRIA 9, including the Green/Duwamish Watershed Alliance, Friends of the Green, and People for Puget Sound. There are many non-profit youth organizations (Student Conservation Corps) which can be hired to conduct a variety of maintenance jobs. Most if not all of the local jurisdictions such as cities, counties, and conservation districts have "adopt-a-park" or other stewardship programs. Ideally, a stewardship program will provide monitoring and stewardship at the same time. Monitoring programs help volunteers become a valued member of the restoration team, and accurate data from these programs provides project managers with a basis for making adaptive management decisions.

In order to maximize benefits to the projects, the Environmental Restoration Study Team (ERST) will pursue all stewardship opportunities available. Long-term stewardship needs to be developed for each project to ensure that the public's natural resources and services are maintained in perpetuity. Each project will depend on finding a viable steward during the project planning efforts since the ERST will not undertake stewardship responsibilities for individual projects. Stewards may include non-profit conservancy organizations, parks and public works departments, and local public interest groups.

11.2 Outreach

Outreach educates the public by giving detailed information as to where projects are located and why the projects are necessary. The ERST strongly advocates active public involvement throughout the implementation of this Restoration Plan. The amount of public involvement will vary with different projects. At a minimum, public involvement will include informational meetings and the required regulatory public notices and hearings. Depending on the guidelines from the project manager, contracting agency or the ERST, specific projects may involve additional public involvement.

Activities that will benefit from public participation include the following: construction activities, such as vegetation plantings, monitoring, data entry; public outreach and education, such as production of interpretive signs and displays, leading field trips to project sites; maintenance, such as debris removal, exotic plant removal, replantings; and project planning through permit reviews and hearings.

12 REFERENCES FOR THE RESTORATION PLAN

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